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OBJECT-LESSON AND EXPERIMENTAL ROADS, AND BRIDGE CONSTRUCTION, 1912-13.

INTRODUCTION.

The United States Office of Public Roads is empowered by a provision of the agricultural act to expend a portion of its appropriation " for investigations of the best methods of road making and the best kinds of road-making materials, and for furnishing expert advice on road building and maintenance."[1] The terms of this clause have been interpreted to include the construction of short stretches of various kinds of roads in different communities for the purpose of serving as object lessons to the officials having charge of the roads and to the citizens who use them. The desire of the office has been to demonstrate in a practical way the need for good roads and at the same time show to the community the proper method of economical road construction.

The work of the office is limited to furnishing the services of one or more expert engineers to make the surveys, estimates, and specifications for the road, to supervise its construction, and to give practical advice to the local authorities who must furnish all machinery, materials, and labor. The community where the road is to be built is first required, through the officials having jurisdiction over the proposed road, to make application to this office on a prescribed form.

As an illustration of the growth of the office the following table is given. It shows the area in square yards of each type of road constructed during the fiscal years 1905 to 1913, inclusive:

Area, in square yards, of object-lesson roads constructed during 1905–1913, inclusive.

Material.	1905	1906	1907	1908	1909	1910	1911	1912	1913[2]
Brick						526			2,055
Concrete						1,004			3,218
Oil-cement concrete							1,917		1,744
Bituminous concrete									5,500
Bituminous-surfaced concrete									4,178
Bituminous macadam						45,832	41,551	34,453	

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[1] Agricultural act, 1914, Public No. 430, 62d Cong., 3d sess. Approved March 4, 1913.

[2] Includes experimental roads.

Area, in square yards, of object-lesson roads constructed, etc.—Continued.

Material.	1905	1906	1907	1908	1909	1910	1911	1912	1913[1]
Surface treatment									10,831
Macadam	44,944	51,246	76,376	72,587	96,107	50,333	11,330	14,806	56,253
Asphalt slag							578		
Oil-asphalt gravel							900		
Oil gravel						4,819	9,774		
Oil-coralline									2,804
Gravel macadam									2,607
Gravel	8,804	4,197	11,722	4,608	65,793	71,376	59,942	13,057	63,730
Slag						4,610			
Sand clay	19,178	19,443	85,571	42,634	205,032	177,960	218,177	103,876	128,496
Sand gumbo									5,337
Burnt clay	400			3,392	2,041				
Shell	5,877	933		14,020	1,630				40,646
Earth		12,132	27,042	85,967	319,456	651,109	140,933	556,663	160,932
Total	79,203	87,951	200,711	223,208	690,059	1,007,569	485,102	722,855	488,331

[1] Includes experimental roads.

During the fiscal year 1912–13 the Office of Public Roads, under the general direction of the chief engineer, Vernon M. Peirce, and the immediate control of the highway engineer in charge, B. F. Heidel, supervised the construction of object-lesson roads as follows: One bituminous-concrete, 1 bituminous-macadam, 7 macadam, 4 gravel, 1 gravel-macadam, 1 brick-cinder, 14 sand-clay, 1 sand-gumbo, 3 shell, and 9 earth. Three other roads begun during the past fiscal year were not completed, and the description of the work on them will be reserved for the next annual report. Exclusive of the assistance afforded by the office in the form of the salaries and expenses of its engineers, the object-lesson roads described below cost the various communities in which they were located $94,323.68.

This bulletin includes, in addition to the object-lesson work of the office, a brief account of the experimental work for the past fiscal year, and reports of the bridge work and inspection of object-lesson roads as conducted under the immediate supervision of Charles H. Moorefield, highway engineer, and E. W. James, chief inspector, who report to the chief engineer.

BITUMINOUS-CONCRETE ROAD.

Chevy Chase Club, Md.—A driveway through the grounds of the Chevy Chase Club, approximately 1,395 feet long, was graded and surfaced with bituminous concrete on a broken-stone base between May 7, 1913, and June 28, 1913. Three days were lost on account of unfavorable weather and 12¾ days for other reasons. The road is 10 feet wide for a length of 150 feet, 15 feet wide for 945 feet, and from 20 to 23 feet wide for 300 feet, making a total area of 2,807 square yards. Of this area 2,602 square yards were surfaced with bituminous concrete and 205 square yards with Portland cement concrete. The maximum cut was 1.5 feet, the maximum fill 0.5 foot, and the maximum grade remained 7 per cent. The adjacent land is rolling and the soil is mica-clay. The drainage structures had all been constructed before this work was begun and were paid for separately.

Four hundred and ninety tons of crushed limestone, all passing a 3-inch mesh screen and retained on a 1-inch mesh screen, were used in constructing the broken-stone base. This material was spread upon the prepared subgrade, so that the compacted depth was 4½ inches. Sixty tons of sand were flushed into the voids in the broken-stone base by sprinkling and rolling. The bituminous concrete was prepared according to the Topeka specifications at the plant of a Washington contractor, and hauled in tarpaulin-covered automobile trucks a distance of approximately 6 miles to the work. The material arrived on the ground at a temperature of approximately 380° F., and was immediately spread upon the completed broken-stone base. It was then rolled, first with a 3-ton tandem roller, and finally with an 8-ton tandem roller, to a compacted thickness of 1½ inches. Pieces of 2 by 4 inch lumber, laid flat at the sides of the road, served as forms to retain the bituminous material during the process of laying and rolling. These were removed, however, upon completion of the rolling and replaced with a sodded earth shoulder. A seal coat of pea gravel and a native asphalt emulsion was finally applied to the surface of the concrete and lightly rolled with a 3-ton tandem roller. The emulsion was applied at the rate of approximately one-tenth gallon per square yard and the gravel at the rate of 1 cubic yard to every 200 square yards of surface.

Automobile parkways having a total area of 205 square yards were constructed of Portland cement concrete mixed in the proportions of 1 part of cement, 2 parts of sand, and 4 parts of crushed limestone. Second-hand 3 by 6 inch lumber was set on edge for forms and the concrete was laid and struck off to a depth of 5 inches, after which the surface was floated with a wooden float.

Seventy linear feet of concrete gutter crossings, having a width of 4½ feet and a total thickness of 6 inches, were constructed. The concrete for the gutter was mixed in the same proportion as that for the parkway, except that the top one-half inch consisted of 1:2 mortar. The total cost of the road, exclusive of drainage structures, was $3,461.56, which is at the rate of $1.211 per square yard.

The principal items of cost were as follows: Grading and preparing the subgrade, 2,807 square yards at $0.174 per square yard, $490.12; total cost of stone for the base f. o. b. siding, 490 tons at $1.10 per ton, $539; loading and hauling the stone (length of haul 1¾ miles), 490 tons at $0.623 per ton, $305.30; sand filler delivered on the work, 60 tons at $1.557 per ton, $93.40; spreading the stone, 490 tons at $0.161 per ton, $79.01; spreading the sand filler, 60 tons at $0.106 per ton, $6.36; rolling the broken-stone base, 2,602 square yards at $0.028 per square yard, $59.27; bituminous concrete at the plant, 2,602 square yards at $0.40 per square yard, $1,040.80; hauling the bituminous concrete from the plant to the road, 2,602 square yards at $0.032 per square yard, $82.50; native asphalt emulsion on the road, 2,602 square yards at $0.012 per square yard, $32.50; gravel for the seal coat, 2,602 square yards at $0.011 per square yard, $28; forms for the bituminous concrete, $5; setting the forms for the bituminous concrete, $21.15; spreading the bituminous concrete, 2,602 square yards at $0.039 per square yard, $101.75; rolling the bituminous concrete, 2,602 square yards at $0.024 per square yard, $62.60; cement concrete automobile parkways, exclusive of preparing the subgrade, 205 square yards at $1.237 per square yard, $278.45; cement concrete gutters, exclusive of the subgrade, 70 linear feet at $0.868 per foot, $60.75; miscellaneous expenses, $58.14; and general expenses, $142.35. The above costs are based on labor at $1.60 and teams at $4.50 for an eight-hour day.

BITUMINOUS-MACADAM ROAD.

Silver Spring, Md.—The seal coat was renewed on the bituminous-macadam drive extending from Silver Spring station to the Blair estate, the construction of which was supervised by the Office of Public Roads during the year 1912 and described in its annual report for that year. Work was begun on June 27, 1913, and completed on July 1, 1913. The road is 2,776 feet in length and 12½ feet wide, making a total area of 3,856 square yards. The road surface was first thoroughly cleaned with stiff brooms, after which a total of 1,075 gallons of a light water-gas tar preparation was applied to the road directly from the drums at the rate of approximately 0.28 gallon per square yard. This material was then distributed by means of hand brooms so as to form a uniform coating over the entire surface. Sixty-six tons of pea gravel were spread over the bituminous material at the rate of approximately 0.0133 cubic yard per square yard. The surface was then lightly rolled with a 10-ton macadam roller.

Several water-bound macadam patches, aggregating 100 square yards in area, were made. Seven and one-fourth cubic yards of crushed limestone and 4¼ cubic yards of limestone screenings were used for this purpose.

The entire cost of renewing the seal coat was $283.78, while the patches cost $49.07. The cost of the road per square yard for the seal coat was $0.0736. The principal items of cost were as follows: Bituminous material, delivered at the station, 1,075 gallons, at $0.095 per gallon, $102.13; loading and hauling the bituminous material to the road, $12.55; pea gravel, delivered at the station, 66 tons, at $1.20 per ton, $79.20; loading and hauling the gravel to the road, $7.05; sweeping the road surface, $8.33; applying the bitumen, $23.83; spreading the gravel, $11.50; rolling, $23.65; limestone for patching the macadam, 11½ cubic yards, at $2 per cubic yard, $23; labor for patching the macadam, $25.57; coal for the roller, $3.50; and general expenses, $12.50. The above costs are based on labor at $1.60 and teams at $4.75 per nine-hour day.

MACADAM ROADS.

Black Rock, Ark.—Work was begun on a macadam road extending from Black Rock westward toward Smithville on September 25, 1912, and discontinued for lack of funds on October 26, 1912, with the loss of 1½ days on account of bad weather.

The land adjacent to the road is hilly, and the natural soil is clay. The road was graded 30 feet wide in cuts and 20 feet wide in fills for 2,600 feet, making a graded area of 7,500 square yards. The maximum cut was 3½ feet, the maximum fill 3 feet, and the total amount of excavation 2,620 cubic yards. Earth was loosened with plows, hauled with drag and wheel scrapers, and spread by hand and with a road grader. The average haul for excavation was 75 feet and the maximum, 300 feet.

A surface of macadam was laid for 1,300 feet, 12 feet wide, making 1,733 square yards. For 660 feet the macadam was applied in two courses, each 5 inches thick at the center and 4 inches at the sides before compacting, and throughout the remaining 640 feet it was applied in one course. In both instances the material was compacted 8 inches at the center and 6 inches at the sides. The material used for surfacing was a hard magnesian limestone with good binding qualities. The run of the crusher was used for both the first and second courses; and the maximum size in the first course was 4 inches and in the second course 2½ inches. "Chats," or the tailings from a zinc mine, were used as a binder in an amount just sufficient to bind the surface properly. This material was similar to that used for surfacing. It ranged in size from one-half inch to dust. The stone was obtained under contract from a local quarry, where a crusher having an average capacity of 50 cubic yards per 10-hour day was already located. The average haul of water for the crusher was three-fourths mile. Stone was brought to the crusher in wheelbarrows, crushed, stored in bins, loaded from the bins into farm wagons which were equipped with dump boards, and hauled to the road for an average distance of 3,500 feet, where it was spread by hand with iron hooks. A 6-ton horse roller was tried for compacting the surface, but was found to be impracticable. The hoofs of the mules loosened the surface as rapidly as it was compacted. No sprinkler wagon was available, and, as the road was constructed during a comparatively dry season, it is probable that the surface could not have been properly bonded, even with a more suitable roller. It was, therefore, left in a loose condition. Before leaving the work, however, the representative of the office instructed the local authorities regarding the proper manner of bonding the road when the weather became suitable.

Drainage structures were constructed as follows: At station 2+50 the existing concrete abutments of a culvert of 13-foot span were extended and the wooden floor was renewed; at station 10+85 concrete wing walls were added to an existing culvert of 4-foot span, and a new wooden floor was constructed; at station 15+55 a new 10-foot span reinforced concrete culvert was constructed; and corrugated iron culverts, 12 inches in diameter and 18 feet long, were placed under approaches to private entrances at stations 4+00, 6+60, 13+25, and 14+15.

The concrete used in the abutments, wing walls, and footings was made of cement and unscreened gravel in the proportion 1:6. In reinforced work cement, sand and screened gravel were used in the proportion 1:2:4, and the concrete used in the parapets was made of cement, sand, and gravel in the proportion 1:2:3.

The equipment consisted of one 6-ton horse roller, two steel road drags, one road grader, and hand tools. Labor cost $1.50 per day of 10 hours, and teams cost $2.50 and $3.

The total cost of the road was $2,153.45, which is at the rate of $1.01 per square yard. The principal items of cost were as follows: Excavation, at $0.203 per cubic yard, $532.25; shaping the subgrade, at $0.0234 per square yard, $40.50; crushed stone, at $0.875 per cubic yard, $405.15; hauling stone from the crusher to the road, at $0.343 per cubic yard, $178.50; spreading stone, at $0.116 per cubic yard, $60; rolling, at $0.04 per square yard, $70; trimming the shoulders and ditches, $46.25; culverts, $1,218.45; and general expenses, $7.50.

Louisville, Ky.—On April 4, 1913, excavation was started on an object-lesson macadam road at Louisville, Ky., and was continued until April 12. The weather conditions were so unfavorable during this period, however, that very little could be accomplished. About $175 was expended, but on account of the continual rain the results of the work done were practically negligible. On April 12 the work was discontinued, but it is hoped that it may be resumed at some more favorable season and the project eventually completed.

Jerusalem, N. C.—Surfacing was started on a road leading from Jerusalem southeast toward South Yadkin River on October 15, 1912, and completed on December 2, 1912. The road had been graded before the arrival of the representative of the Office of Public Roads, and no data concerning the cost of grading could be obtained. The land adjacent to the road is rolling, and the soil is sandy loam from station 0+00 to station 13+00 and red clay from station 13+00 to station 20+00. The macadam surface is 2,210 feet long and 12 feet wide, making a total area of 2,950 square yards. The stone consisted of coarse-grained light granite for the foundation course and trap or field stone for the wearing surface. The compacted depth of the foundation course was 3¾ inches, and of the top course, including the screenings, 2¼ inches. Surfacing material to the amount of 655 cubic yards was used, and of this 364 cubic yards was purchased.

Concrete gutters 1 foot wide, 3 inches thick, and dished from 1 inch to 2 inches, were constructed on each side of the road throughout its length. Cross drains 14 feet long, of bell-joint pipe, were constructed at stations 3+00, 5+50, 10+75, 13+00, and 18+50. The diameter of the first four drains was 4 inches and of the last 6 inches. The ditches for the cross drains in each case were filled with broken stone. Underdrains of 6-inch bell-joint pipe 12 feet, 33 feet, 40 feet, and 16 feet long were constructed at stations 3+00, 5+50, 10+75, and 13+00, respectively. Concrete drop inlets 10 inches square and 2 feet deep, having 3-inch walls, were provided for these drains. Three hundred and seventy-four sacks of cement were used in constructing the gutters and drop inlets.

The equipment consisted of a crusher having an average capacity of 50 cubic yards per 10-hour day, a 10-ton roller, a sprinkling cart, and slat-bottom road wagons. The crusher and roller were both borrowed, and the only cost in connection with their use was the operating and maintenance expenses. The average haul from quarry to crusher was one-half mile and from crusher to road 500 feet. The water for the crusher, roller, and sprinkler was pumped.

The total cost of surfacing the road was $2,073.07, and the rate per square yard $0.703. Labor cost $1.40 per day, teams $3 per day, and fuel $6 per ton. The principal items of cost were: Materials for concrete gutters and drop inlets, $192.30; labor for these gutters and inlets, $120.05; drainpipe, $17.16; labor for the drainpipe, $7.07; surfacing material, $273; quarrying, $243.54; hauling to the crusher, $251.52; crushing, $136.38; hauling from the crusher to the road, $153.45; spreading, $140.17; sprinkling, $13.50; rolling, $13.13; hire of the sprinkler, $25; explosives, $99.50; crusher repairs, $25; drill steel, $28.40; sharpening the drill steel, $16.40; fuel, $62.10; lubricating oil, $12.50; loosening old macadam, $16.80; screening, $2.80; clearing, $25.90; and general expenses, $197.40.

MONROE, N. C.—A macadam road leading southeast from Monroe toward Wingate, known as the Lee Mill Road, was started on October 12, 1912, and completed on November 22, 1912, and during this time 3⅓ days were lost on account of unfavorable weather. This road had been graded before the arrival of the office representative, and no data relative to the cost of grading were available. The grade varies from a maximum of 3 per cent to level. The adjacent land varies from rolling to hilly, and the soil is red clay and clay shale. Local sandstone was used for surfacing. This stone possesses good wearing qualities, but poor binding qualities, making it a good material for the foundation course, but not well suited for the top course.

The total length surfaced was 2,510 feet and the width 10 feet, giving a surfaced area of 2,789 square yards. The stone was laid in three courses—the bottom course consisting of stone varying in size from 1¾ inches to 4 inches, the second course from 1 inch to 1¾ inches, and the top course from dust to 1 inch. The total compacted depth of the surface was from 7½ inches to 9 inches. The crown of the finished roadway was three-fourths inch to 1 foot. Stone to the amount of 1,133 cubic yards was crushed, but only 997 cubic yards was used. The stone was hauled from the quarry to the crusher for an average distance of 175 feet in wheelbarrows, and from the crusher to the road for an average distance of 2,000 feet in slat-bottom wagons with a capacity of approximately one cubic yard. The stone was loaded directly from the bins into the wagons. Water for the crusher engine was carried 200 feet by hand, and hauled 300 feet for the roller. Four tons of fuel was used at the crusher and 5½ tons by the roller.

The equipment consisted of a stone crusher having 73 cubic yards' capacity per 9-hour day, an engine, a 10-ton roller, slat-bottom wagons, and hand tools. Convict labor and teams owned by the county were used. The cost to the county per day per convict and per mule was $0.45. The total cost of the road was $647.15, making a rate of $0.232 per square yard.

The principal items of cost were: Preparing the subgrade, $22.95; quarrying, $117.45; hauling to the crusher, $66.60; crushing, $50.40; hauling from the crusher to the road, $112.94; spreading the stone, $22.95; sprinkling, $8.11; rolling, $68.95; stacking and loading screenings, $31.05; shaping shoulders, $11.70; loss of time due to bad weather, $57.35; and incidental expenses, $76.70.

NORTHWILKESBORO, N. C.—Work was begun on a macadam road leading from Northwilkesboro toward Wilkesboro on October 2, 1912, and was discontinued on December 21, 1912. Thirteen and one-half days were lost on account of bad weather. A section of road 800 feet in length was entirely completed and an additional length of 494 feet was partially completed. The section completed follows the Yadkin River, and the entire road is subject to overflow at flood seasons. To remedy this condition the grade of the road was raised and the macadam was laid on a Telford base.

The natural soil is clay and silt and the adjacent land is level. There was no cut, and the maximum fill was 3.9 feet and the average fill 2.1 feet. The maximum grade of 5.85 per cent was reduced to 2.5 per cent.

A total length of 1,294 feet was graded 30 feet wide. All the material for the embankment was taken from pits located at an average distance of three-eighths mile from the road and in no case more than one-half mile. It was loosened with a plow, loaded with shovels on slat-bottom wagons, and spread by hand.

A subgrade 16 feet wide was prepared for a distance of 1,294 feet and a Telford base 12 inches thick was laid upon it for the same distance. A macadam surface was laid upon this base to the same width for a distance of 800 feet. The surface was laid in two courses, each 3 inches thick compacted, and each course was bonded with screenings. The stone used on the bottom course consisted of pieces from 1½ to 3 inches in size, and the stone used in the second course ranged from one-half inch to 1½ inches. The screenings consisted of material ranging from dust to particles one-half inch in size.

The Telford base and the macadam surface were both made from mica gneiss obtained from the same quarry. This material possesses excellent binding and wearing qualities. It was quarried at an average distance of 1½ miles from the road, crushed at the quarry, loaded into dump wagons by means of a chute from the bins, and hauled to the road, where it was spread with forks.

The following drainage structures were constructed: One reinforced concrete culvert 2 by 4 feet by 29 feet long; one reinforced concrete culvert 2 by 6 feet by 30 feet long; one reinforced concrete culvert 2 by 6 feet by 28.5 feet long; and one wooden-box culvert 2 by 3 feet at an intersecting road.

The equipment consisted of one stone crusher with a capacity of 25 cubic yards per day, elevator, bins, one 10-ton roller, six 1½ cubic yard dump wagons, slat-bottom wagons, one turn plow, and hand tools.

The labor cost for men was $0.12½, $0.13½, and $0.15 per hour, and double teams cost $0.30 per hour. The working day was 10 hours long.

The total cost of the road was $3,293.29, which is at the rate of $1.8875 per square yard. The principal items of cost were as follows: Excavation and embankment, 979 cubic yards, at $0.40 per cubic yard, $391.60; clearing and grubbing, 2,300.4 square yards, at $0.0017 per square yard, $4; shaping the subgrade, 2,300.4 square yards, at $0.06 per square yard, $139.58; Telford foundation, 2,300.4 square yards, at $0.489 per square yard, $1,124.01; quarrying and crushing the surfacing materials, 380 cubic yards, at $1.525 per cubic yard, $579.49; hauling the surfacing materials, 380 cubic yards, at $0.645 per cubic yard, $245.30; spreading the surfacing materials, 380 cubic yards, at $0.108 per cubic yard, $40.93; sprinkling and rolling, 1,422.2 square yards, at $0.15, $213.63; reinforced concrete drainage structures, $473; and general expenses, $40.63. The above costs do not include any charge for the use of the stone crusher, elevator, and bins.

JONESVILLE, VA.—Between May 1 and October 17, 1912, a macadam road was built under the direction of the office at Jonesville, Va., and during this time 37 days were lost on account of bad weather and 5 days from other causes. The adjacent land is hilly and the natural soil is clay and gravel. The road was graded to a width of 20 feet for 8,200 feet, with the exception of a short section which was constructed 24 feet wide. For 2,200 feet the road was located on the side of a hill, and in this section 50 per cent of the excavation was solid rock. The total area graded was 21,860 square yards, and the maximum grade was reduced from 17 to 9 per cent. The total volume of earth and rock moved was 7,590 cubic yards and the maximum haul 800 feet. A macadam surface 6,800 feet in length was constructed upon a part of the graded section, 10 feet wide for a length of 4,500 feet, 12 feet wide for 1,800 feet, and 24 feet wide for the remaining 500 feet. The total area surfaced was 8,735 square yards. The surfacing material—a limestone of good binding but only fair wearing qualities—was obtained from a quarry five-eighths mile from the road. It was crushed at the quarry in a crusher having 50 cubic yards' capacity per 10-hour day, and after being hauled to the road in slat-bottom wagons of 1½ cubic yards' capacity was spread in three courses with forks and shovels. The first or foundation course, 7 inches in thickness before compacting, consisted of pieces varying from 2 to 3 inches in size; the second course, 3 inches thick, consisted of pieces from one-half inch to 2 inches in size; and the third or binder course, applied to a depth of approximately 1 inch, consisted of pieces varying in size from 1 inch to dust. Each course was compacted with a 10-ton roller, and was bonded in the usual manner with a sprinkler wagon and roller.

Culverts were constructed of corrugated-iron pipe as follows: At stations 10, 14, and 20, 12 inches in diameter and 22 feet in length; at station 17, 12 inches in diameter and 24 feet in length; at station 20, 15 inches in diameter and 24 feet in length; at stations 28 and 82, 24 inches in diameter and 40 and 26 feet in length, respectively; and at stations 43 and 52, 30 inches in diameter and 26 and 24 feet in length, respectively. End walls of rough stone were constructed at all culverts.

The equipment consisted of a 10-ton roller, a rock crusher, 5 wheel scrapers, 1 turn plow, 1 rooter plow, 2 dump carts, 1 steam drill, and hand tools. Labor cost $1.50 and teams $3.50 per day. The other principal items of cost were as follows: Excavation, at $0.36 per cubic yard, $2,726.95; shaping the subgrade, at $0.024 per square yard, $206.10; quarrying and crushing the stone, at $0.93 per cubic yard, $3,142.47; hauling the stone, at $0.166 per cubic yard, $506.30; spreading the stone, at $0.07 per cubic yard, $228.90; sprinkling, at $0.0075 per square yard, $60.85; rolling, at $0.02 per square yard, $183.70; trimming the shoulders, $31.30; lowering the water pipes and raising the walks, $48; culverts, $261.56; supervision and general expenses, $382.20; making the total cost of the road $7,778.33 This is at the rate of $0.837 per square yard.

NORTON, VA.—The work of macadamizing the Wise-Norton road was begun on August 1, 1912, and discontinued on December 15, 1912, after 3,360 linear feet or 4,340 square yards had been surfaced. The work was done by contract, and the grading and culvert work had been finished before the macadamizing was started. Twenty-four days were lost owing to bad weather and 27½ days from other causes. The land adjacent to the road is hilly and the soil is yellow clay. The maximum grade is 6 per cent and the minimum 1.2 per cent. Limestone, which was used for the surfacing was put on in three courses, having respective depths, measured loose, of 6 inches, 3 inches, and ¾ inch, and a total compacted depth of 6¾ inches. Surfacing material to the amount of 1,298 cubic yards was used, and of this 1,005 cubic yards was local stone, while 293 cubic yards was purchased and brought by rail. The local stone was quarried and transported 50 feet to the crusher by means of a tram car. After crushing, it was stored in bins having capacities of 50, 30, and 20 cubic yards, and loaded directly into slat-bottom wagons and dump cars of approximately 1.2 cubic yards capacity. The wagons were drawn by teams and the dump cars by a traction engine. The average haul from the crusher to the road was 4 miles. The stone that was shipped was hauled 70 miles by rail. Water was piped 900 feet for the crusher and hauled 1 mile for the roller and sprinkler. A vitrified clay-pipe culvert at station 9+00 was broken during the surfacing, having been placed too near the surface. In replacing it 26 feet of 18-inch pipe and 2½ cubic yards of concrete were used. At the crusher 45¾ tons of fuel were used and 14 tons by the roller. The explosives used at the quarry cost $118.92.

The equipment consisted of a crusher and engine having a capacity of 150 tons per 10-hour day, slat-bottom wagons, a sprinkler, a roller, hand tools, etc., and a traction engine was hired at $10 per 10-hour day. Labor and teams cost, respectively, $0.15 and $0.35 per hour, and fuel cost $1.75 per ton.

The total cost of the work was $3,630.22, which is at the rate of $0.837 per square yard. The principal items of cost were: Shaping the subgrade, $374.13; replacing the culvert at station 9, $55.53; surfacing material, $366.25; quarrying, $951.05; crushing, $254.06; hauling the stone to the road, $892.35; spreading the stone, $240.60; sprinkling, $112.35; rolling, $350; and loading stone at the car, $33.90.

This work was resumed on April 18, 1913, and the project was entirely completed on July 12, 1913. During this period five days were lost on account of unfavorable weather and two days from other causes. The last section surfaced had not been graded throughout its length as the section above described had. On this part the maximum cut was 1½ feet and the maximum fill 3 feet; the maximum grade remained 4 per cent, as on the old road. The land adjacent to this section is hilly and the soil is shale clay underlain by a bed of blue marl. In grading, the earth was loosened with plows, hauled with drag scrapers, and spread by hand. Between stations 43 and 54+10 the foundation was of an inferior character. Subdrainage was therefore provided by digging a ditch along the gutter and filling part of it with sandstone and part with limestone, and laying tile drain in the remainder. Cross drains were constructed every 25 feet between the above stations. Other necessary drainage structures had been constructed before the work began. The equipment was the same as that used on the first section described above.

The average haul for the excavation was 200 feet and the maximum haul was 400 feet. The average haul from the crusher to the road was 3½ miles. The surface of this section was constructed entirely of local limestone having good binding qualities and fair wearing qualities. Material was hauled in slat-bottom wagons of 1 cubic yard capacity and dump wagons of 2 cubic yards capacity, and by means of the tractor outfit.

The road was surfaced for 3,900 feet to the following widths: Twenty-four feet wide for 1,110 feet, 16 feet wide for 2,090 feet, and 12 feet wide for 700 feet, making a total surfaced area of 7,609 square yards. It was necessary to grade the road for a distance of 500 feet to a width of 30 feet in cuts and 22 feet in fills, making a total graded area of 1,489 square yards. The surfacing material was spread in three courses, which, when measured loose, were, respectively, 6 inches, 3 inches, and 1 inch deep. The total compacted depth was 6 inches. The material used in the first course ranged in size from 3 inches to 1¾ inches; that used in the second course, from 1¾ inches to three-fourths inch; and that used in the third course, from three-fourths inch down to and including the dust of fracture. The crown of the finished surface was three-fourths inch to 1 foot.

One thousand cubic yards of earth were excavated, 2,261 cubic yards of surfacing material were crushed, and 2,114 cubic yards used, while 24 tons of coal were used by the crusher and 19 tons by the roller. In constructing the underdrains 1,575 feet of 3-inch vitrified pipe and common land tile and 55 cubic yards of crushed stone were used.

The cost of labor, teams, etc., amounted to approximately the same as in the preceding section. The total cost of the road to the community was $5,071.99, making the cost per square yard $0.666.

The principal items of cost were as follows: Excavation to the extent of 1,000 cubic yards, at $0.141 per cubic yard, $141.15; shaping the subgrade, 8,676 square yards, at $0.078 per square yard, $673.35; 55 cubic yards of limestone for underdrains, at $2.40 per cubic yard, $132; 1,575 linear feet of tile, at $0.034 per foot, $52.86; labor on the underdrains, $185.83; trimming the shoulders and ditches, $20.95; general expenses, $292.34; quarrying 2,261 cubic yards of limestone, at $0.551 per cubic yard, $1,247.32; hauling this stone to the crusher, at $0.086 per cubic yard, $195.12; crushing it at $0.121 per cubic yard, $273.08; hauling 2,114 cubic yards of stone from the crusher to the road, at $0.563 per cubic yard, $1,190.80; spreading it, at $0.09 per cubic yard, $190.40; sprinkling 7,609 square yards, at $0.004 per square yard, $31.40; rolling 7,609 square yards, at $0.049 per square yard, $371.50; and explosives used in the quarry, $73.89.

It is interesting to note that the cost of hauling the stone from the crusher to the road, a distance of 3½ miles, by means of wagons was approximately $1 per cubic yard, while the cost of hauling by means of the tractor outfit was only about $0.21 per cubic yard. The tractor outfit, however, can not be used except during dry weather.

GRAVEL ROADS.

Jonesboro, Ark.—A gravel road leading from Jonesboro eastward toward the State agricultural school was begun on September 23, 1912, and entirely completed on October 25, 1912, with the loss of 5½ days on account of unfavorable weather and 3 days from other causes. The adjacent land is rolling and the soil throughout the length of the road is clay. A section 3,348 feet long was graded for a width of 30 feet in cuts and 24 feet in fills, giving a total area of 9,822 square yards. The gravel surface is 3,050 feet long and 15 feet wide, making a surfaced area of 5,083 square yards. Three timber bridges having a width of roadway of 16 feet were constructed, having respective dimensions as follows: No. 1, length 8 feet 6 inches, clear span 6 feet 6 inches, and height of opening 4 feet 8 inches; No. 2, length 16 feet 8 inches, clear span 15 feet, and height of opening 2 feet 6 inches; and No. 3, length 16 feet 4 inches, clear span 14 feet 8 inches, and height of opening 4 feet 6 inches.

The maximum grade was reduced from 3.7 per cent to 2.5 per cent, while the minimum grade remained 0.1 per cent. The maximum cut was 1.7 feet and the maximum fill 1.4 feet. Two thousand and seventy cubic yards of earth was excavated for an average haul of 350 feet and a maximum haul of 800 feet.

This material was loosened with plows, hauled in drag and wheel scrapers, and spread with shovels.

The surfacing material consisted of sandy chert gravel possessing fair binding qualities and excellent resistance to wear. The gravel was applied in two courses, the first course having a loose depth of 7 inches at the center and 5 inches at the sides, and the second course a loose depth of 4 inches at the center and 3 inches at the sides. The total compacted depth was 8 inches at the center and 6 inches at the sides, and the crown of the finished roadway was three-fourths inch to 1 foot. The gravel for both courses ranged in size from 3½ inches to fine sand. The surfacing material, of which 1,357 cubic yards was used, was delivered on the road at the contract prices of $1.15 per cubic yard for 1,171 cubic yards and $1.25 per cubic yard for 186 cubic yards.

The equipment consisted of one 6-horse road machine, one road plow, one 5-ton horse roller, 8 No. 1 wheel scrapers, 4 No. 2 drag scrapers, and hand tools. The grader outfit, including teams and operators, was hired at the rate of $14 per 10-hour day. Labor cost $2, teams $4.67, and foremen $2.67 and $4 per 10-hour day.

The total cost of the road to the community was $2,703.69, which is at the rate of $0.511 per square yard. The principal items of cost were as follows: Excavation, at $0.335 per cubic yard, $693.20; shaping the subgrade at $0.018 per square yard, $101; surfacing material, delivered, $1,579.15; spreading the surfacing material, $75.80; rolling, $19.09; explosives, $3.16; materials for the culverts and stakes, $12.08; labor for the culverts, $6.80; trimming the shoulders, $7.71; incidental expenses, $109.70; and superintendence, $96.

COLUMBUS, MISS.—On July 22, 1912, work was begun on a section of the Tuscaloosa road, extending from Columbus eastward toward the Alabama State line, and it was completed on September 16, 1912. The adjacent land is level and the natural soil a sandy clay. The road was graded 20 feet wide for 2,291 feet, making an area of 5,095 square yards. Earth to the amount of 5,778 cubic yards was moved, and the maximum grade was reduced from 5 to 0.1 per cent. The earth was loosened with plows, picks, and shovels, loaded with shovels into wagons, hauled in wagons and drag scrapers, and spread with shovels and a small grader. The average haul was 450 feet and the maximum haul 700 feet. The total area surfaced was 3,564 square yards. Two types of surfacing materials were used—a good cementing gravel for 1,166 feet and a loose pit gravel for 1,125 feet. The former material, donated by an abutting property owner, was spread upon the prepared subgrade in a single course 7 inches thick before being compacted. It compacted readily under the action of traffic, and the surface was maintained in proper shape by frequent dressing with a road grader. The pit gravel was spread upon the clay subgrade to a depth of 6 inches, and it was expected that it would be mixed with the clay by the traffic, but when the representative of the Office of Public Roads left it was still in a loose, uncemented condition. A total of 636 cubic yards of gravel was used.

Drainage structures were constructed as follows: At station 4+25 a reinforced concrete bridge with 18 feet 6 inches of roadway, a span of 15 feet, and 4.2 feet height of opening; and at station 9+70 a reinforced concrete bridge, with 18 feet 6 inches of roadway and 6.5 feet height of opening, and two 15-foot spans. Both bridges were constructed by contract, with the exception of the center pier of the second bridge, which was built under force account.

The equipment consisted of road plows, drag scrapers, a small road grader, and hand tools.

Based on labor at $1 per day and teams at $3, the principal items of cost were as follows: Clearing and grubbing, at $0.017 per square yard, $84.20; excavation and embankment, at $0.206 per cubic yard, $1,189.35; fine grading, at $0.007 per square yard, $11.90; loosening and loading gravel, at $0.165 per cubic yard, $104.70; hauling gravel, at $0.234 per cubic yard, $148.80; spreading gravel, at $0.0057 per square yard, $20.60; trimming shoulders and ditches, $5.70; culverts, $1,106.45; and general expenses, $10. The total cost of the road was $2,681.70, which is at the rate of $0.75 per square yard. If the cost of drainage structures is excluded, the cost per square yard is reduced to $0.442.

Belton, Tex.—The road leading from Belton eastward toward Temple, approximately 5¼ miles long, known as the Air Line Road, was graded, drained, and surfaced with gravel. This road is about equally divided between Belton precinct and Temple precinct, and on account of the separate road organizations in these two separate precincts it was necessary to construct the road in two sections. Each of these sections will be described in turn.

The Belton section.—Work was started on this section on December 26, 1912. Surfacing was started on March 26, 1913; and excavation was completed on May 22, 1913, and surfacing on June 30, 1913. All work was finished on July 3, 1913. Unfavorable weather caused the loss of 16⅔ days, and 16½ days were lost from other causes.

The earth was loosened by plows, hauled by drag scrapers, and spread by means of a road machine. The maximum cut was 1½ feet and the maximum fill 5.7 feet. The maximum grade was reduced from 6.4 per cent on the old road to 5 per cent on the new road.

The adjacent land is rolling, and the soil for the first 650 feet is loose rock; for the next 925 feet, gumbo; for the next 1,700 feet, sandy; for the next 3,000 feet, sand-clay; for the next 500 feet, gumbo; for the next 600 feet, loose rock; and for the remainder of the distance to station 124—the end of the section—gumbo. A corrugated iron pipe culvert, 12 inches in diameter and 24 feet long, was constructed at station 73+65.

The equipment consisted of 2 road graders, 5 No. 3 drag scrapers, 3 No. 2 drag scrapers, 1 railroad plow, 1 turn plow, 7 wagons, shovels, picks, etc. The wagons were slat-bottom, having a capacity of 1⅙ cubic yards, and were used for hauling gravel.

The average haul for the excavation was 110 feet, and the maximum haul 600 feet. The average haul from the gravel pit to the road was 4,920 feet, and the average haul of water for the roller 1½ miles.

The natural soil was used in the foundation throughout the road. Gravel for surfacing was obtained from several different sources, and varied from rather poor to excellent in quality. It was spread on the road partly by means of hand raking and partly with a steel drag and a road machine.

The total length of the road graded was 12,606 feet for a width of 32 feet in cuts and 26 feet in fills, making a total graded area of 42,920 square yards. The total length of surface was 12,010 feet, and the width was 24 feet for 925 feet, and 18 feet wide for the remaining distance, making a total surfaced area of 24,637 square yards. The gravel was spread sometimes in one course and sometimes in two courses. The loose depth of the first course ranged from 5 to 10½ inches, and that of the second course from 1½ to 3¾ inches, while the total loose depth ranged from 5 to 10½ inches. The crown of the finished surface varied from three-quarters to 1 inch to 1 foot according to the steepness of the grade.

Earth to the amount of 5,268 cubic yards was moved in grading; and 5,503 cubic yards of gravel was used in surfacing, of which 4,733 cubic yards was purchased and 770 yards donated.

Convict labor cost $0.60; hired labor from $0.75 to $2.50; and teams from $3 to $3.50 for a 9-hour day. The total cost of the work was $4,144.33, which is at the rate of $0.167 per square yard.

The principal items of cost were as follows: 5,268 cubic yards of excavation, at $0.143 per cubic yard, $739.15; shaping the subgrade, at $0.002 per square yard, $45.42; 24 feet of culvert pipe, at $0.50 a foot, $12; labor for culverts, $5.75; 4,733 cubic yards of gravel, at $0.05 per cubic yard, plus $150 for the pit, $386.65; loosening and loading the gravel, 5,503 cubic yards, at $0.15 per cubic yard, $825.89; hauling 5,503 cubic yards of gravel from the pit to the road, at $0.318 per cubic yard, $1,753.10; spreading the gravel, at $0.054 per cubic yard, $295.11; working and finishing the surface, $60.52; trimming the shoulders and ditches, $18.80; and explosives, $1.94.

The Temple section.—This section extends from station 124 to station 276+80. The first work was excavation, and this was begun on December 26, 1912, and finished on June 18, 1913. The surfacing was started on March 26, 1913, and finished on July 3, 1913. The road was entirely completed by July 5, 1913. Twenty-two days were lost on account of unfavorable weather and 6.9 days from other causes. Earth in excavation was loosened by plows and hauled in wagons and in drag and wheel scrapers, while rock was loosened with picks, bars, and dynamite, and hauled in wagons. Culverts were constructed as follows: Station 128+10, 12-inch concrete pipe, 30 feet long; station 134+35, 30-inch concrete pipe, 26 feet long; station 148+40, 12-inch concrete pipe, 34 feet long; station 154+10, 42-inch concrete pipe, 56 feet long; and station 172+27, 8 feet by 6 feet reinforced concrete culvert with 18-foot roadway. The maximum cut was 3.2 feet, and the maximum fill, 13.9 feet, and the maximum grade was reduced from 8.6 per cent to 5 per cent. The adjacent land is rolling and the soil varies in character; it is gumbo for the first 3,400 feet, loose rock for the next 500 feet, gumbo for the next 1,200 feet, yellow clay over shale limestone for the next 500 feet, gumbo for the next 1,800 feet, loose rock for the next 1,600 feet, gumbo for the next 1,000 feet, soft ledge limestone for the next 700 feet, and gumbo for the remainder of the distance to station 276+80. The equipment consisted of one 10-ton roller, one 10-barrel tank wagon, one 600-gallon sprinkling wagon, 2 road graders, 1 rooter plow, 1 railroad plow, 1 turn plow, 3 No. 2 wheel scrapers, 6 No. 2 and 2 No. 3 drag scrapers, two 16-foot sections of collapsible culvert forms, slat-bottom wagons, picks, shovels, etc. The wagons had a capacity of approximately 1⅛ cubic yards and were used for long-haul grading and for hauling gravel.

The average haul for excavation was 140 feet and the maximum haul 950 feet. The average haul from the gravel pit to the road was 10,320 feet. Water was conveniently obtained from a pipe at the roadside. The gravel used was chert and limestone, and it was loaded on the wagons by means of shovels and drag scrapers.

The total length of the road graded and surfaced was 15,223 feet for a width of 32 feet in cuts and 26 feet in fills, making a total graded area of 50,830 square yards. The width surfaced was 18 feet throughout, making the surfaced area 30,446 square yards. Part of the gravel was spread in one course and part in two courses. The loose depth of the first course varied from 4 to 6½ inches, and of the second course from 1 to 5½ inches. The total loose depth varied from 4½ to 10 inches. The crown of the finished surface was from three-fourths inch to 1 inch to 1 foot. Earth to the amount of 5,927 cubic yards and rock to the amount of 145 cubic yards were moved in excavation, and 5,877 cubic yards of gravel was used in surfacing. Two hundred and fifteen sacks of cement, 2,740 pounds of steel, 67 cubic yards of gravel, 2,750 feet, board measure, of lumber, one-half coil of wire, 64 feet of 12-inch concrete pipe, and 36 feet of 30-inch concrete pipe were used in culverts. Convict labor cost $0.60, hired labor from $0.80 to $2, and teams from $2.20 to $3.50 per nine-hour day.

The total cost of the road to the community was $6,221.55, which is at the rate of $0.204 per square yard or $2,157.25 per mile. The principal items of cost were 6,072 cubic yards of excavation, at $0.158 per cubic yard, $962.48; shaping the subgrade, at $0.001 per square yard, $43.28; 100 feet of concrete pipe, at $0.853 per foot, $85.31; labor for concrete pipe, $31.73; 8-foot by 6-foot culvert, $397; 42-inch pipe culvert, $350; surfacing material in the pit, $348.75; loosening and loading, 5,877 cubic yards of surfacing material, at $0.137 per cubic yard, $803.47; hauling surfacing material from the pit to the road, at $0.465 per cubic yard, $2,733.71; spreading the surfacing material, at $0.047 per cubic yard, $273.63; finishing and rolling, $81.22; trimming the shoulders and ditches, $22.27; 12 tons of coal, at $6 per ton, $72; and incidental expenses, $16.70.

GRAVEL-MACADAM ROAD.

Bentoak, Miss.—Work on a road extending from Bentoak southward toward the Gilmer Road was begun on October 14, 1912, and discontinued because of unfavorable weather conditions, on December 18, 1912. During this time 3 days were lost on account of bad weather. The adjacent land is rolling and the soil is a very stiff post-oak gumbo. For a distance of 2,185 feet the road was graded 24 feet wide in cuts and 20 feet wide in fills, making an area of 5,350 square yards graded, for which 900 cubic yards of material was moved. The maximum grade was reduced from 7.5 to 3.6 per cent. The earth was loosened with plows and picks, loaded by hand and with shovels, hauled with slip and wheel scrapers and dump-board wagons, and spread with shovels and slip scrapers. The average haul was 630 feet and the maximum haul 1,150 feet. Two kinds of material were used for surfacing—a soft limestone and a clay cementing gravel. The limestone was found in ledges at a maximum depth of 3 feet below the surface and an average distance of one-half mile from the road. It was broken by hand into suitable sizes on the road. The gravel, on the other hand, was purchased and delivered in cars at a convenient siding, with a haul of about 750 feet. The road for 1,955 feet was surfaced 12 feet wide with two methods, and the entire area surfaced was 2,607 square yards. According to the first method, which was followed in surfacing 1,720 square yards, a foundation course of rock was spread with shovels and rakes 6 inches deep after compacting, and upon it a surface course of gravel was spread with a road grader to a depth of 4 inches after compacting, while the second method, which was used in surfacing the remaining 887 square yards, consisted in spreading a single course of rock to a depth of 6 inches after compacting. The crown adopted for both types of road was 1 inch to 1 foot. The total volume of rock was 450 cubic yards and of gravel 260 cubic yards. Cross drains were constructed as follows: At station 0+75 a 16-inch cast-iron culvert 21 feet long and at station 19+17 a reinforced concrete culvert of 3 feet span, 30-inch height of opening, and 20 feet length.

The equipment consisted of road and turn plows, 6 slip scrapers, 2 wheel scrapers, 1 road grader, and 1 split-log drag. The estimated cost of the convict labor, which was used exclusively, was $1 per day, and, while all teams used on the work were loaned to the local authorities free of charge, a money value of $3 per day per team was assumed for these contributions. This corresponded with local prices for teams.

The principal items of cost, based on the above prices, were as follows: Clearing and grubbing, $46.55; excavation and embankment, at $0.55 per cubic yard, $494.36; shaping the subgrade, at $0.028 per square yard, $72.69; quarrying rock, at $0.91 per cubic yard, $410.83; hauling rock, at $0.47 per cubic yard, $211.14; placing, spreading, and "napping" rock, at $0.097 per cubic yard,

$43.75; gravel, $54; freight on gravel, $86; unloading gravel cars at siding, at $0.043 per cubic yard, $11.29; loading gravel wagons, at $0.154 per cubic yard, $40; hauling gravel, at $0.125 per cubic yard, $32.44; placing and spreading gravel, at $0.038 per cubic yard, $10; trimming ditches and shoulders, $62.86; culverts, $135.59; and general expenses, $34.65.

The total cost of the road was $1,746.15, which is at the rate of $0.686 per square yard for the gravel section and $0.406 per square yard for the rock section.

BRICK-CINDER ROAD.

Columbus, Miss.—The work at Columbus, Miss., which consisted in grading and surfacing a section of what is known as the Military Road, extending from Columbus toward the Alabama State line, was begun on September 18, 1912, and completed on October 9, 1912. The adjacent land is hilly, and the natural soil is sand and clay. For 2,128 feet the road was graded 30 feet wide in cuts and 20 feet in fills, giving an area of 2,615 square yards. A total volume of 1,696 cubic yards of earth was moved, resulting in lowering the maximum grade from 1.5 to 0.4 per cent. The earth was loosened with a plow, picks, and shovels, hauled in wagons and slip scrapers, and spread with shovels. The average haul was 250 feet and the maximum 900. The surfacing materials consisted of brickbats and brick-kiln cinders, donated by a local brick manufacturer. Both materials were loaded on dump-board wagons at the brickyard, hauled an average distance of one-half mile, and spread upon the prepared subgrade with shovels and potato hooks. The brickbats, which were used in the foundation course, were broken with hammers at the road, and were spread to a width of 14 feet and a depth of 4 inches after compacting, while the surface course was composed of the cinders spread to a width of 16 feet and a depth of 4 inches after compacting. The road was compacted principally by the action of traffic, but a short section was rolled with a road roller loaned by the authorities of the city of Columbus. The road was surfaced for 1,243 feet, and the area of the foundation course was 1,933 square yards, requiring 322 cubic yards of brickbats. The area of the surface course was 2,210 square yards, upon which 343 cubic yards of cinders were used. The road is one of the most heavily traveled roads in the county, but judging from results obtained upon a similar road in the same locality, it is expected that the surface will wear well if it is given proper attention.

The equipment consisted of a road plow, slip scrapers, and a small road grader. With labor at $1 per day and teams at $3, the principal items of cost were as follows: Excavation, at $0.14 per cubic yard, $236.15; clearing and grubbing, $20.75; trimming the shoulders and ditches, $9.40; labor on the pipe culvert, $2.75; loading brickbats, at $0.202 per cubic yard, $65.35; hauling brickbats, at $0.413 per cubic yard, $133.25; spreading brickbats, at $0.063 per cubic yard, $20.45; loading cinders, at $0.187 per cubic yard, $63.70; hauling cinders, at $0.323 per cubic yard, $110.65; spreading cinders, at $0.035 per cubic yard, $12.10; and general expenses, $7.20. The total cost of the road was $681.75, which is at the rate of $0.26 per square yard for the completed section.

SAND-CLAY ROADS.

Brooksville, Fla.—Work was started on the Bayport Road, which leads west from Brooksville toward Bayport, on March 10, 1913, and was completed on April 16, 1913. The land adjacent to the road is rolling and the soil is clay from station 0 to station 19, and a natural mixture of sand and clay from station 19 to station 24. The maximum cut was 2 feet and the maximum fill

2½ feet. The maximum grade was reduced from 4½ per cent to 3½ per cent. The equipment consisted of one 2-horse plow, 5 drag scrapers, one 6-horse road grader, slat-bottom wagons, picks, shovels, etc. Labor cost $1.75 and teams $5 per 10-hour day.

The improvement consisted in grading and shaping the existing road and surfacing it with a sand-clay mixture. The earth was loosened with plows and hauled in wagons and on drag scrapers for an average haul of 700 feet and a maximum haul of 1,900 feet. The material was spread and the road shaped by means of the road grader. One drainage ditch was constructed leading away from the road at station 25. The ditch was 5 feet wide by 1 foot deep by 300 feet long. Clay for surfacing was hauled an average distance of one-half mile, and the sand an average distance of three-fourths of a mile. These materials were spread in uniform layers of 7 inches and 3 inches, respectively, and thoroughly mixed.

The road was then shaped so that the crown of the finished surface was 1 inch to 1 foot. Five days were lost on account of unfavorable weather and six days from other causes. The weather and labor conditions were largely responsible for the high cost of this work.

The road was graded to a length of 2,400 feet, with a width of 28 feet in cuts and 20 feet in fills. The entire length was surfaced to a width of 16 feet, making the surfaced area 4,267 square yards. Earth to the amount of 1,450 cubic yards was moved in excavation, and 1,500 cubic yards of surfacing material was used. The total cost of the road to the community was $1,351.51, which is at the rate of $0.317 per square yard. The principal items of cost were: Excavation, 1,450 cubic yards, at $0.30 per cubic yard, $432; shaping the subgrade, at $0.031 per square yard, $130.63; clearing and grubbing, $15.50; trimming the shoulders and ditches, $55.38; excavating 303.3 cubic yards of sand, at $0.15 per cubic yard, $45.50; loosening and loading 830 cubic yards of clay, at $0.109 per cubic yard, $90.49; hauling clay, 830 cubic yards, at $0.265 per cubic yard, $220; loosening and loading 660 cubic yards of sand, at $0.116 per cubic yard, $76.38; hauling sand, 660 cubic yards, at $0.24 per cubic yard, $158.75; spreading sand, 660 cubic yards, at $0.019 per cubic yard, $12.25; spreading clay, 830 cubic yards, at $0.021 per cubic yard, $17.50; mixing sand and clay, 4,267 square yards, at $0.0035 per square yard, $15; final shaping, at $0.0035 per square yard, $15; and general expenses, $67.13.

QUITMAN, GA.—Work was begun on a sand-clay road extending from Quitman toward Spain, on January 30, 1913, and completed on February 21, 1913, with the loss of five days on account of bad weather. The adjacent land is rolling and the natural soil is sand from station 0 to station 15, clay from station 15 to station 22, sand from station 22 to station 30, clay from station 30 to station 34, sand from station 34 to station 44, clay from station 44 to station 48, and sand from station 48 to station 61.

A total length of 6,100 feet was graded 30 feet wide in cuts and 20 feet wide in fills, making 15,000 square yards. Earth was excavated to the amount of 1,050 cubic yards, and the average haul was 375 feet and the maximum haul, 500 feet. Throughout its entire length the road was surfaced to a width of 14 feet, making 9,489 square yards. The sand-clay surface was constructed as follows: The sand and clay were spread uniformly in two courses of 4 inches and 8 inches in loose depth, respectively. These materials were then thoroughly mixed first with a plow and then with a disk harrow, after which the road was shaped with a road grader. It was immediately opened to traffic and as ruts were formed they were filled by dragging. Clay to the amount of 1,590 cubic yards was hauled to the road, dumped, and spread by hand with shovels. Sand was used to the amount of 790 cubic yards, a part of which was hauled and spread by hand while the rest was obtained from the sides of the road and spread with the road grader. The binding qualities of the clay and the wearing qualities of the clay and sand appear to be very good.

Cross drains, 28 feet long, were constructed of 10-inch and 24-inch sewer pipe at stations 25 and 55, respectively.

The equipment consisted of one 6-mule grader, 1 rooter plow, 1 turn plow, 1 disk harrow, wagons, and hand tools.

The total cost of the road was $513.55, which is at the rate of $0.054 per square yard. The principal items of cost were as follows: Excavation, at $0.11 per cubic yard, $115.05; shaping the subgrade, at $0.002 per square yard, $19.50; loading and hauling clay, at $0.15 per cubic yard, $235.59; spreading clay, at $0.015 per cubic yard, $23.10; loading and hauling sand, $30.72; spreading sand, $2.40; mixing, at $0.0025 per square yard, $24.26; trimming shoulders, $8.80; stripping and refilling clay pits, $19.84; moving fences, $4.65; and culverts, $29.64. The above costs were based upon a labor cost of $0.60 per day of 10 hours, and a cost for teams of $1 per day of 10 hours. Convict labor and county teams were used.

TALBOTTON, GA.—Work on the sand-clay road known as the Centerville Road, which was begun during the fiscal year 1912, but which, owing to unfavorable weather conditions, was discontinued on January 6, 1912, was resumed on August 20, and finally completed on August 24, 1912. During the previous year the road was graded 30 feet wide for 3,525 feet and surfaced 14 feet wide for 1,950 feet. When the work was resumed this surface was found to be in excellent condition with the exception of slight inequalities resulting from a lack of proper care as the road dried out in the spring. The surface, constructed last year, was extended 1,625 feet, with a width of 14 feet, making 2,528 square yards, upon which 614 cubic yards of surfacing material was used. This material, which was hauled an average distance of 1 mile, consisted of red clay and fine loamy sand, and the clay was spread 4 inches deep before compacting and the sand 8 inches. As in the previous work, the crown adopted was three-fourths inch to 1 foot. The section between stations 34+25 and 35+25 was slightly inferior owing to the fact that the subgrade was wet and had not fully settled when the surface was laid. An additional amount of sand was used on this section, however, and it is expected that it will eventually be as good as the rest of the road. The force employed was the regular county road force, and was made up of 23 convicts, 3 guards, a superintendent, and 19 mules. Convict labor cost $0.50 per day and teams $1. The principal items of cost were as follows: Loading surfacing material, at $0.062 per cubic yard, $38.25; hauling surfacing material, at $0.091 per cubic yard, $56; spreading surfacing material, at $0.001 per square yard, $2.25; mixing, at $0.0075 per square yard, $18.50; shaping, at $0.002 per square yard, $5; repair and maintenance, $10; and camp care for convicts, $17.50, making the total cost of the work performed this year $147.50. The cost of work previously completed was $1,067.31, and the total cost of the road was, therefore, $1,214.81, which is at the rate of $0.22 per square yard.

HOUSTON, MISS.—A section of sand-clay road was constructed in Chickasaw County, leading north from Houston toward Houlka. This road is locally known as the Pontotoc Road. A survey was made on April 22, 1913, and grading was begun on April 25, 1913. The road, as originally planned, was not completed under the supervision of the Office of Public Roads. This was due to the fact that sufficient force was not employed to justify continuing the assignment. On May 29, 1913, the work was turned over to a competent foreman with a view to continuing it after the office representative was withdrawn. The land adjacent to the road is slightly rolling and the soil varies from a heavy plastic clay to a loam clay rich in lime, with blue clay occurring from station 17 to station 20. The maximum cut was 0.3 foot and the maximum fill 1.6 feet. The maximum grade was reduced from 3.4 to 2.9 per cent. The minimum grade remained level. Labor cost $1 and teams $3 per 10-hour day.

The road was constructed by grading and shaping the old road, providing the necessary drainage structures, and surfacing with a mixture of sand-clay. The sand used in surfacing was obtained from a pit and mixed with clay from the road. The sand was hauled in ordinary farm wagons having a capacity of approximately 1 cubic yard, and the mixing was done with disk and spike-tooth harrows and plows. The final finishing and shaping was done with a split-log drag. Two reinforced concrete pipe culverts were constructed, each 16 feet in length. The one at station 33 had a diameter of 30 inches and the other at station 42+81 had a diameter of 24 inches. The forms for these culverts consisted of collapsible cylinders and the reinforcement of heavy woven-wire fencing. The end walls of the 30-inch culvert were 10 feet long and 9 inches thick. Those of the 24-inch culvert were 9 feet long and 8 inches thick. The equipment consisted of one 8-horse road grader, 1 road plow, 2 No. 1 drag scrapers, 1 split-log drag, 1 disk harrow, 1 spike-tooth harrow, collapsible culvert forms, picks, shovels, etc.

The total length graded was 4,080 feet. The width graded was 26 feet in cuts and 20 feet in fills, making a total graded area of 11,787 square yards. For 2,450 feet the road was prepared for surfacing, but only 1,150 feet was finished. The width surfaced was 14 feet, making a total surfaced area of 3,344.4 square yards. The sand was spread to a loose depth of 6 inches and the crown of the finished roadway was 1 inch to 1 foot. In the excavation 692 cubic yards of material was moved, with an average haul of 10 feet and a maximum haul of 50 feet. Sand to the amount of 583.3 cubic yards was used for surfacing and the average haul from the sand pit to the road was 1.7 miles. In the construction of the culverts 12.3 cubic yards of concrete was used, and the gravel for this work was hauled by rail for a distance of 76 miles, and then by wagon 0.6 mile from the siding to the road.

Cement cost $0.55 a sack and gravel $1.155 per cubic yard f. o. b. siding. The total cost of the road to the community was $696.43, and the cost per square yard, taking each item of cost separately and disregarding culverts, was approximately $0.158. The principal items of cost were as follows: Clearing and grubbing, $7.25; rough grading 692 cubic yards, at $0.0942 per cubic yard, $65.20; preparing the subgrade, 3,700 square yards, at $0.0057 per square yard, $21.05; loading sand, 583.3 cubic yards, at $0.0612 per cubic yard, $35.70; hauling sand, 583.3 cubic yards, at $0.6182 per cubic yard, $360.60; spreading sand, 583.3 cubic yards, at $0.031 per cubic yard, $18.10; mixing 3,344.4 square yards, at $0.0086 per square yard, $28.90; shaping 6,211.1 square yards, at $0.0012 per square yard, $7.25; superintendence, $38.40; and incidentals, assembling tools, etc., $4.80. The total cost of the drainage system was $109.18, and this figure may be divided into the following items: Labor on the ditches, $16.80; excavating for the culverts and backfilling over them, $11.40; hauling the gravel, cement, and water 0.6 mile, $14.05; labor on the forms, $4.20; mixing and placing the concrete, $8; 18 cubic yards of gravel, at $1.155 per cubic yard, $20.79; 52 sacks of cement, at $0.55 per sack, $28.60; 50 feet b. m. lumber, at $16 per thousand, $0.80; 8 rods of heavy woven-wire fence, at 28 cents per rod, $2.24; 6 pounds of nails, at $0.05 per pound, 30 cents; and 2 gallons of linseed oil, at $1 per gallon, $2.

MOSCOW, MISS.—A section of clay road 4,150 feet in length at Moscow, Miss., was partially relocated, graded, and surfaced with sand-clay. The graded width was 30 feet and the surfaced width 17 feet. This road lies between De Kalb and Moscow, and is a part of what is known as the Jackson Road. The adjacent land is hilly. Work was begun on September 20, 1912, and was completed on November 5, 1912. The only sand available for surfacing was very fine grained and of poor quality. It was obtained from a pit and hauled to the road in farm wagons for approximately 1.5 miles.

The grading was done with a road machine, a railroad plow, and five slip scrapers. The total area graded was 13,833 square yards, and the cost of grading was $282.04. No record was kept of the quantity of material moved in grading. The subgrade was shaped for surfacing at a cost of $0.003 per square yard, or $20.58 for the 7,839 square yards surfaced.

Sand to the amount of 1,524 cubic yards was used for surfacing, and the cost of surfacing was distributed as follows: Hauling 1,524 cubic yards of sand, at $0.49 per cubic yard, $743.20; spreading 1,524 cubic yards of sand, at $0.007 per cubic yard, $10.60; and mixing 7,839 square yards of surface, at $0.006 per square yard, $48.54; making the total cost of surfacing $802.34.

The other items of expense were: Ditching, $25.55; clearing and grubbing, $41.38; excavation for a bridge, $2.80; general expenses (foreman, cook, etc.), $112.42; and miscellaneous expenses (camp, trips for provisions, etc.), $34.50. This makes a total cost to the community of $1,321.61, or a cost per square yard of $0.096.

All grading and other work on the road was done by the county convict force with county teams, and the cost per convict was $0.40 per day, and the cost per team $0.80 per day. The surfacing material was hauled by contributed labor, the money value of which has been rated at $1 per day per man and $2.50 per day per team.

Calypso, N. C.—A section of road leading from Calypso southeast toward Kenansville was graded and surfaced between September 4 and September 14, 1912. The adjacent land is slightly rolling and the soil is sandy throughout the length of the section. The grading consisted in plowing the ditches and bringing the road to the proper cross section with a road machine. A small amount of material was moved for an average distance of 50 feet with drag scrapers. For 1,650 feet the road was graded 24 feet wide and surfaced 14 feet wide, making the area graded 4,400 square yards and the area surfaced 2,563 square yards. The crown of the finished roadway was three-fourths inch to 1 foot. Clay to the amount of 248 cubic yards was hauled an average distance of 2,400 feet, and 55 cubic yards of sand was hauled an average distance of 1,760 feet. Farm wagons having an approximate capacity of 1 cubic yard were used for hauling both sand and clay. They were loaded and unloaded with shovels. Two corrugated-iron culverts were ordered for this work, but were not received before the surfacing was completed. Directions were furnished for placing them.

The equipment consisted of 1 road machine, 1 rooter plow, 1 turn plow, 1 split-log drag, 2 drag scrapers, 1 disk harrow, farm wagons, and hand tools. Labor cost $1 and $1.50 per day and teams cost $1.20 and $2.50 per day. The total cost of the work was $133.60, which is at the rate of $0.0521 per square yard. The principal items of cost were: Grading and shaping the subgrade, $38.60; loading sand, $3.75; hauling sand, $6.25; spreading sand, $1.50; loading clay, $22.65; hauling clay, $49.25; spreading clay, $5.50; mixing clay and sand, $4.80; and final shaping with a drag, $1.60.

Jerusalem, N. C.—A sand-clay road running from Cooleemee northeast to Jerusalem was begun on September 3, 1912, and completed on October 18, 1912. The land adjacent to the road is rolling and the soil varies from "black jack" gravel to micaceous clay. This road had been graded to a width of 24 feet in cuts and 18 feet in fills, and the drainage structures were all completed before the object-lesson work was begun.

The sand for use in surfacing was loosened with plows, loaded with hand shovels, hauled approximately 1¼ miles in slat-bottom wagons, and spread with grader and by hand. The subgrade prepared for surfacing was 20,020 feet long and 16 feet wide, making a total area of 35,590 square yards. The same area was given a sand-clay surface 6 inches thick after compacting, with a crown of three-fourths of an inch to 1 foot. For the surfacing 4,820 cubic yards of material was used, approximately 3,000 cubic yards of which had to be purchased. The cost of labor was $1.25 per day, and of teams $3 per day.

The total cost of the work was $1,799.61, which is at the rate of $0.0506 per square yard. The principal items of cost were: Loading sand, at $0.0605 per cubic yard, $291.61; mixing surfacing materials, at $0.001 per square yard, $37.25; shaping, at $0.0015 per square yard, $53.25; spreading sand, at $0.0137 per cubic yard, $66; hauling sand, at $0.2546 per cubic yard, $1,227; purchase of sand pits, $105.25; and general expenses, including water boy, etc., $19.25. The cost of superintendence, which is included above, was 6.32 per cent of the total cost.

Lexington, N. C.—A sand-clay surface was constructed at Lexington on Fifth Avenue south from Center Street, toward the southbound railroad station. The work was begun on July 22, 1912, and was completed on August 22, 1912. The adjacent land is rolling and the natural soil is clay of a plastic nature but lacking in toughness.

The first work was grading. The earth was loosened by means of a traction engine and a road plow, loaded and hauled with drag scrapers, wheel scrapers, and wagons, and spread with shovels. The maximum cut was 4 feet and the maximum fill 3 feet. The maximum grade was reduced from 3 per cent to 1 per cent.

The equipment consisted of 3 No. 2 wheel scrapers, 6 No. 2 drag scrapers, 2 plows, three 1½-cubic-yard dump wagons, one 12-horsepower traction engine, picks, shovels, etc. The average haul for excavation was 150 feet and the maximum haul 400 feet. The sand mixed with the clay for surfacing was obtained from a pit and hauled for an average distance of 3 miles in 1-cubic-yard slat-bottom wagons. The quality of the sand was excellent for the purpose for which it was used. Free labor cost $1.25 and $1.50, and foreman $3 per 10-hour day. Convict labor was estimated at $1 per day, and teams cost from $2 to $3 per day.

The total length graded was 3,000 feet, and the width graded, both in cuts and fills, was 30 feet, making the total area graded 10,000 square yards. The entire length of 3,000 feet was surfaced for a width of 18 feet, making the area surfaced 6,000 square yards. The compacted depth of surfacing material was 4 inches and the crown three-fourths of an inch to 1 foot. The earth excavation amounted to 3,975 cubic yards, and the sand used for surfacing amounted to 815 cubic yards. The total cost of the work was $1,177.45, which is at the rate of $0.196 per square yard of surfaced area. The principal items of cost were: Excavation, 3,975 cubic yards, at 11 cents per cubic yard, $440.35; hauling 815 cubic yards of sand, at 80 cents per cubic yard, $652; spreading 815 cubic yards, at $0.016 per cubic yard, $12.75; mixing the sand and clay, $60.60; sprinkling, $6; and general expenses, $5.75.

Aransas Pass, Tex.—A section of Commercial Street extending east from Wheeler Avenue to the city limits was given a sand-clay surface during the past fiscal year. Excavation was started on November 21, 1912, and the work was entirely completed by December 16, 1912, with the loss of only one day on account of unfavorable weather. A total length of 5,000 feet was graded to a width of 16 feet in cuts and 18 feet in fills and surfaced to a width of 16 feet throughout, making a total area of 8,890 square yards for the surfaced roadway.

The adjacent land is approximately level and the soil consists of fine loose sand. Eight hundred and ninety cubic yards of earth was moved in excavation, with a maximum cut of 2 feet and a maximum fill of 2.5 feet. The excavated material was loosened with plows, hauled for an average distance of 200 feet in wheel scrapers and dump wagons, and spread with a road machine. The maximum and minimum grades remained respectively 0.2 per cent and level.

In order to increase the stability of the sand foundation, a layer of sea moss, 2 inches thick before compacting, was spread before applying the surfacing material, and 117 wagon loads of moss were used. The surfacing material, which consisted of a natural sand-clay mixture, was then spread to a depth of 7½ inches loose or 5 inches compacted, and a crown of 1 inch to 1 foot was given the roadway. The material for the surfacing amounted to 1,823 cubic yards. It was hauled 1,000 feet in slat-bottom wagons and spread with a road machine. This material was delivered by contract at $0.50 per cubic yard.

Labor cost $1.50 and teams cost $3.50 and $4 per 9-hour day. The total cost of the road to the community was $1,397.13, which is at the rate of $0.157 per square yard. The principal items of cost were as follows: Excavation, at $0.348 per cubic yard, $309.58; surfacing material, delivered, at $0.50 per cubic yard, $911.50; spreading the surfacing material, at $0.011 per square yard, $20; loading and spreading the moss, $82.05; shaping the finished roadway, $8; and superintendence and general expenses, $66.

Corpus Christi, Tex.—During the fall of 1912 a sand-clay road was constructed at Corpus Christi, extending in a northwesterly direction toward Calallen. Work was begun on October 8, 1912, and completed on November 29, 1912, and during this time five days were lost on account of bad weather. The land adjacent to the road is rolling and the nature of the soil is sand-clay throughout, with clay predominating from station 0 to station 20, while from station 20 to station 54 sand predominates. In all, 5,400 feet was graded 45 feet wide, making 27,000 square yards. The maximum cut was 1 foot and the maximum fill 3.5 feet, and the grade was reduced from 6.5 per cent to 5 per cent. The volume of excavation was 6,700 cubic yards, and the average haul was 200 feet and the maximum haul 700 feet. Throughout its entire length the road was surfaced with a natural sand-clay mixture of good binding and wearing qualities for a width of 16 feet and a compacted depth of 6 inches, making 9,600 square yards of surface covered, or 2,140 cubic yards of material used. The material was spread with a road grader.

The crown adopted was one-half inch to 1 foot. The road was so located that the principal problem presented was that of securing proper drainage. To this end the grade was raised and six existing culverts were replaced by three new ones of greater capacity, constructed as follows: At station 11+20 a 24-inch vitrified clay pipe 39½ feet long; at station 24+20 two 36-inch corrugated metal pipes 24 feet long, replacing two 24-inch vitrified clay pipes; at station 43+00 a reinforced concrete box culvert, 6 feet in span, 4½ feet in height of opening, and 22 feet in length; and at station 51+50 an old 24-inch vitrified clay pipe culvert was allowed to remain in place. All of the pipe used was found on the ground, and the concrete culvert was built by contract.

The equipment consisted of 1 road grader, 4 wheel scrapers, 5 drag scrapers, 1 plow, three 1½-cubic-yard wagons, 1 disk harrow, and 1 tooth harrow.

Labor cost $1.40 per 10-hour day and teams $1. The principal items of cost were as follows: Excavation, at $0.107 per cubic yard, $715.70; shaping subgrade, at $0.0007 per square yard, $10.89; clearing and grubbing, $44.99; hauling the surfacing material, at $0.065 per cubic yard, $138.84; mixing, at $0.0011 per square yard, $10.92; labor for pipe culverts, $33.65; contract price of end walls for pipe culverts, $66; contract price of box culvert, $154.50; and cost of hauling materials for the concrete, not included in contract price, $43.25. The total cost of the road was $1,218.74, which is at the rate of $0.127 per square yard.

JEWETT, TEX.—Work was started on August 22, 1912, on a sand-clay road running from Jewett westward toward Newby and completed on September 7, 1912. The land adjacent to the road is rolling, and the soil is sandy throughout the section surfaced. In grading, the earth was loosened by plowing and hauled in drag scrapers for an average distance of 50 feet. A section 10,500 feet long was graded for a width of 40 feet and surfaced for a width of 14 feet, making the area graded 46,666 square yards and the area surfaced 16,333 square yards. Earth to the amount of 4,350 cubic yards was moved in the excavation, and 4,100 cubic yards of clay was used for surfacing. The clay was hauled for an average distance of 1,350 feet and spread to a depth of 9 inches, measured loose, but on account of the continued dry weather it could not be successfully mixed with the sand. Specifications were furnished by the representative of the Office of Public Roads, however, for properly mixing the materials when the weather became favorable, and this part of the work was let to contract. Five wooden culverts, 24 feet in length, were constructed, with the following cross sectional dimensions: Two 4 feet by 2 feet, one 10 feet by 2½ feet, and two 16 feet by 3 feet. Three thousand seven hundred and fifty feet b. m. of pine timber and 24 oak posts were used for these culverts.

The equipment consisted of one 2-horse blade ditcher, plows, slat-bottom wagons, and hand tools. Labor cost $1.75 per 10-hour day and teams $4. The total cost of the work was $3,017.08, which is at the rate of $0.184 per square yard. The principal items of cost were: Clearing and grubbing, $28.75; excavation and embankment, $608.75; loosening and loading clay, $637.75; hauling clay, $1,183.75; spreading clay, $74.75; trenching for clay at the side of the road, $30; shaping with the grader, $27.50; contract price for mixing, $150; materials for culverts, $121.44; labor for culverts, $51.76; superintendence, $75; and general expenses, $27.63.

PEARSALL, TEX.—A section of road in Frio County leading northeast from Pearsall toward Bigfoot, known as the Sand Hollow Road, was improved by surfacing with sand clay. The work was begun on February 20, 1913, and continued until March 31, 1913. Eight days were lost on account of rain and 7½ days for other reasons. The adjacent land is rolling and the soil is a fine sandy loam. The maximum and minimum grades remained respectively 2 per cent and level. The existing grade of this road was such that the only grading necessary was done with the road machine. The only exceptions to this were at stations 23 and 27, where the material obtained in uncovering the clay pit was hauled to fill several holes in the road. Labor cost from $1.10 to $1.25 and teams $3 per 10-hour day.

The road was constructed by first carefully shaping it with a road machine and then spreading a wearing course of clay over the surface. The road was then reshaped by means of the road machine. The clay used for surfacing contained a considerable amount of sand, and possessed excellent binding and wearing qualities. It was spread by hand with shovels and hoes, and was obtained from pits and hauled in 1-cubic-yard slat-bottom wagons. At station

37 a wooden box 1½ by 2 by 24 feet was constructed. This was the only drainage structure provided. The equipment consisted of 1 road machine, 8 ¼-yard drag scrapers, 8 slat-bottom wagons, 1 heavy road plow, picks, shovels, etc.

The total length of the road was 4,700 feet and the width both in cuts and fills was 26 feet, making a graded area of 13,578 square yards. The entire length of 4,700 feet was prepared for surfacing, but only 4,200 feet was surfaced. The width of the surface was 15 feet, making a total surfaced area of 7,000 square yards. The surfacing material was spread to a depth of 8 inches compacted and given a crown of three-fourths inch to 1 foot. The clay used for surfacing amounted to 1,556 cubic yards and was hauled for an average distance of 1,050 feet. In constructing the wooden box culvert at station 37, 406 feet b. m. No. 1 pine was used. The total cost of the road to the community was $926.90, making the cost per square yard of surfaced area $0.132. The principal items of cost were: Grading and shaping the subgrade, $42.40; filling holes with material stripped from the clay pits, $22.25; timber for the culvert, $12.75; stripping the clay pits, $143; loosening and loading clay, 1,556 cubic yards at $0.183 per cubic yard, $284.72; hauling clay, 1,556 cubic yards at $0.228 per cubic yard, $355.50; spreading clay, 1,556 cubic yards at $0.032 per cubic yard, $50.70; dragging, $11.70; and trimming shoulders, $3.88.

San Antonio, Tex.—A section of the road leading from San Antonio south toward Laredo was improved by grading and surfacing with sand and clay. The section is 1 mile in length and approximately 20 miles south of San Antonio. The work was started on January 7, 1913, and completed on February 14, 1913, with the loss of 5½ days on account of rain and bad weather. The adjacent land is rolling, and the soil is a sandy loam upon a clay subsoil throughout the entire road. The maximum cut was 1.7 feet and the maximum fill 1.6 feet. The maximum grade was reduced from 3.7 to 2.8 per cent. Labor cost $1.50 and teams $3.45 per nine-hour day.

The road was constructed by spreading a surface course of clay over the natural sand soil used in the foundation. At stations 4+30 and 37+30, where streams are forded, it was necessary to construct stone curbing on either side of the clay surface to protect it from washings. The curb at station 4+30 was 20 feet by 12 inches by 18 inches, and that at station 37+30 was 24 feet by 12 inches by 18 inches.

The road was graded for a total length of 5,280 feet. The width in cuts was 40 feet and in fills 24 feet, making the total area graded 23,467 square yards. The entire length of 5,280 feet was surfaced to a width of 16 feet, making the surfaced area 9,387 square yards. In grading it was necessary to excavate 2,775 cubic yards of earth, and 1,825 cubic yards of clay was used in surfacing. The earth was loosened with plows and hauled a short distance with wheel and Fresno scrapers. The clay was obtained from pits and hauled an average distance of 305 feet in wagons. The equipment consisted of 1 eight-horse road grader, 1 disk harrow, 2 plows, 1 spike-tooth harrow, 5 No. 1 wheel scrapers, 3 five-foot Fresno scrapers, 1 three-foot Fresno scraper, 2 No. 2 slip scrapers, wagons, picks, shovels, etc.

The clay was spread to a loose depth of 7 inches, and the crown of the finished surface was three-fourths inch to 1 foot. The total cost of the road to the community was $1,261.57, which is at the rate of $0.134 per square yard. The principal items of cost were as follows: Clearing and surfacing the entire road, $81.25; moving and rebuilding fences, $73.34; moving a house from the right of way, $19.56; constructing curbing, 2.4 cubic yards, at $2.24 per cubic yard, $5.38; excavating 2,775 cubic yards of earth, at $0.1149 per cubic yard, $318.86; loading, hauling, and spreading 1,825 cubic yards of clay, at $0.2864 per cubic yard, $522.65; stripping clay pits, $52.91; back-filling clay pits, $88.20; mixing clay and sand, 9,387 square yards, at $0.0069 per square yard, $64.78; and shaping the surface, 23,467 square yards, at $0.0015 per square yard, $34.64.

FRANKTOWN, VA.—A sand-clay road leading from Franktown toward Eastville and known as the Eastville Road was begun on September 4, 1912, and left as completed on October 14, 1912. The road subsequently became unsatisfactory, however, and a representative of the Office of Public Roads was detailed to investigate the causes and to supervise such additional work as the conditions seemed to warrant. Work was resumed on January 20, 1913, and the project finally completed on February 1, 1913. Altogether 4 days were lost on account of bad weather.

The land adjacent to the road is rolling, and the soil is sand from station 0 to station 12; clay from station 12 to station 15; sand from station 15 to station 25; and clay from station 25 to station 34. The maximum grade was reduced from 5 per cent to 2 per cent, and the maximum cut was 5 feet and the maximum fill 4 feet. In grading, the earth was loosened with plows, hauled with drag scrapers, and spread with shovels. The total amount moved was 1,500 cubic yards. For 3,400 feet the road was graded 30 feet wide and surfaced 15 feet wide, giving an area of 11,333 square yards graded and 5,666 square yards surfaced. Clay was spread to a depth varying from 4 inches to 12 inches and mixed with an 8-inch course of sand. The crown of the finished road was 1 inch to 1 foot.

The total cost of the road to the community was $670.60, which is at the rate of $0.118 per square yard. The principal items of cost were: Grading, $289.51; clearing and grubbing, $61.27; shaping the subgrade, $19.50; loading and hauling the clay, $137.75; loading and hauling the sand, $87; mixing the sand and clay, $26.90; shaping, $25.37; trimming the shoulders, $8.75; and constructing road intersections, $14.75. Labor cost $1.25 per 10-hour day and teams $2.50, $3, $4, and $4.25.

SAND-GUMBO ROAD.

COLUMBUS, NEBR.—A section of sand-gumbo road extending northwest from the Platte River toward Columbus was constructed during the fiscal year 1912 and was described in the last annual report of the Office of Public Roads. The work was resumed on August 19, 1912, and an additional section 3,002 feet long was graded to a width of 32 feet in cuts and 24 feet in fills and given a sand-gumbo surface 16 feet wide. The additional area graded was 10,228 square yards and the additional area surfaced 5,337 square yards. The section was completed on September 4, 1912.

In the excavation 760 cubic yards of earth was moved, and the maximum cut was 1.3 feet and the maximum fill 2.7 feet. The maximum grade was reduced from 13.2 per cent to 4.4 per cent. The adjacent land is level and the soil is sandy. The earth was loosened with plows and hauled in drag, Fresno, and wheel scrapers for an average haul of 160 feet and a maximum haul of 350 feet.

The surfacing material consisted of a good quality of black gumbo and sharp, clean sand. The gumbo was spread to a depth of 7½ inches and the sand to a depth of 6 inches, both measured loose. The two materials were mixed by means of plows and harrows and shaped with a steel drag and a road machine. The compacted depth of the finished surface was 8 inches and the crown was three-fourths inch to 1 foot. In this work 1,165 cubic yards of gumbo and 890 cubic yards of sand were used. The gumbo was hauled approximately 2 miles in slat-bottom dump wagons having a capacity of 1 cubic yard, and the sand was hauled 4,000 feet in the same wagons.

The outfit consisted of 4 drag scrapers, 2 Fresno scrapers, 1 wheel scraper, one 8-horse road machine, 1 steel road drag, 1 plow, 1 disk harrow, 1 spike harrow, and hand tools. Labor cost $2 and teams $4 per 10-hour day.

The total cost of the road to the community was $1,663.15, which is at the rate of $0.311 per square yard. The principal items of cost were as follows: Excavation, at $0.158 per cubic yard, $120; shaping the subgrade, at $0.005 per square yard, $28.20; loading gumbo, at $0.155 per cubic yard, $180.40; hauling gumbo, at $0.60 per cubic yard, $698.80; spreading gumbo, at $0.029 per cubic yard, $34; loading sand, at $0.105 per cubic yard, $93.60; hauling sand, at $0.336 per cubic yard, $299; spreading sand, at $0.012 per cubic yard, $10.60; mixing, at $0.007 per square yard, $37.20; rolling, at $0.0025 per square yard, $13.60; shaping, at $0.001 per square yard, $4; shoulders and ditches, $46.40; purchase of gumbo pit, at $125 per acre, $41.35; miscellaneous, $14; and superintendence, $42.

SHELL ROADS.

Fort Myers, Fla.—A shell road leading from Fort Myers toward Punta Rassa, known as the McGregor Boulevard, was begun on May 15, 1912, and completed on December 11, 1912. This road was constructed in two sections—one section lying within the corporate limits of Fort Myers and paid for by the municipality, and the other outside of the corporate limits and paid for by the county. The land adjacent to the road is approximately level and the soil is sandy throughout.

The town section (waterbound).—The town section was 7,200 feet long, and was graded to a width of 28 feet outside to outside of shoulders or 36 feet between curbs. The shell surface replaced an old surface of the same kind which had become badly worn, and extended the entire length of the section. It was 16 feet wide and the surfaced area was 12,800 square yards. The shell was spread 12 inches deep and compacted to 6 inches. The total amount of shell used was 3,838 cubic yards, all of which was purchased at a cost of $1.0203 per cubic yard. Two hundred and five feet of vitrified clay culvert pipe, ranging in diameter from 15 inches to 24 inches, was used. A reinforced concrete girder bridge, having a span of 24 feet, a width of roadway of 24 feet, and a 6-foot height of opening, was constructed at station 59. This bridge was constructed by contract and cost $1,540.

The total cost of the road, exclusive of the concrete bridge, was $6,539.36, making a rate of $0.511 per square yard. The cost of labor was $1.50 per 10-hour day and of teams $5 per day. The principal items of cost were: Clearing, fine grading, and trenching, $579.60; scarifying the old road, $115.50; culvert pipe delivered, $183.70; labor for pipe culverts, $70; surfacing material at dock, $3,915.96; hauling the surfacing material from the dock to the road, $1,186.35; spreading the surfacing material, $334.25; and rolling, $154. Wood for fuel for the roller was cut by county convict force and the cost is not included.

The equipment consisted of a 10-ton road roller, slat-bottom wagons, and hand tools. The average haul for shell was 1 mile and for water for the roller ½ mile.

The county section (bituminous).—The county section was 9,100 feet long and had been partially graded before the object-lesson work was begun. The available cost data concerning grading were, therefore, not complete. The width graded was 24 feet and the width surfaced 16 feet, making a total area of 24,267 square yards graded and 16,178 square yards surfaced. The shell was spread to a depth of 14 inches in the center and 10 inches on the sides, and compacted to 7 inches in the center and 5 inches on the sides. The shell was old and rotten and ranged in size from whole oyster shells to small fragments.

After this material had been spread and partially compacted, a thin bituminous binder was applied to the surface cold, at the rate of one-half gallon per square yard, and left undisturbed until the next day. Shell fines and sand were then spread over the bitumen and the surface was rolled until thoroughly compacted. The length of road treated with bitumen was 8,950 feet and the area 15,911 square yards.

Vitrified clay pipe, 108 feet by 24 inches, half-round corrugated iron pipe, 56 feet by 60 inches, and circular corrugated pipe, 32 feet by 48 inches, were used in constructing culverts.

The equipment consisted of a 10-ton roller, a road grader, slat-bottom wagons of 2½ cubic yards' capacity, and hand tools, and labor cost $1.50 per 10-hour day for men and $5 for teams. The cost was distributed as follows: Clearing, grading, and ditching (estimated), $1,800; wood for fuel for the roller, $150; shaping the subgrade, 16,178 square yards, at $0.00644 per square yard, $104.25; culvert pipe, $595.88; labor on the culverts, $136.25; shell for surfacing, 5,608 cubic yards, at $1.0125 per cubic yard, $5,678.55; hauling the shell, 5,608 cubic yards, at $0.446 per cubic yard, $2,499.75; spreading the shell, 5,608 cubic yards, at $0.0678 per cubic yard, $380.25; sprinkling, 16,178 square yards, at $0.00513 per square yard, $83; rolling, 16,178 square yards, at $0.01845 per square yard, $298.50; trimming the shoulders and ditches (41,000 feet), $175.75; bitumen, 8,089 gallons, at $0.09 per gallon, $728; demurrage on car, $81; hauling the bitumen, $68; spreading the bitumen, 15,911 square yards, at $0.00613 per square yard, $97.50; applying shell fines and sand, 15,911 square yards, at $0.00778 per square yard, $123.75; and incidentals, $6.

The total cost of the road to the community was $13,006.43, which is at the rate of $0.804 per square yard.

ANNAPOLIS, MD.—Several sections of road aggregating approximately 7,052 feet in length upon the grounds of the United States Naval Academy at Annapolis were improved between April 17, 1913, and May 16, 1913. The land adjacent to these roads is nearly level and the soil has been made by filling with various materials, such as clay, brick, shells, etc. The maximum cut and the maximum fill were each about 0.5 foot, since the grading was essentially only a matter of correcting slight irregularities in the grade of the old roads. The cost of labor was $1.28, and of 1-horse teams $2 per 8-hour day.

The equipment consisted of one 4½-ton tandem roller, one 10-ton macadam roller, 1 spike-tooth harrow, 1 water wagon, one 2-horse grader, carts, picks, shovels, etc. The average haul for excavation was 1,000 feet and the maximum haul, 2,000 feet. The hauling was done in carts having about ½ cubic yard capacity. Shell for surfacing was brought by water for a distance of about 40 miles and hauled in 25-bushel carts 800 feet from the scow to the road. It was not necessary to provide any additional culverts or other drains on any part of the work.

The improvement consisted in shaping the old road, a considerable part of which had been previously surfaced with shell, and constructing a new oyster-shell surface. The wearing quality of the shell was apparently not very good. The surfacing was done in seven sections having the following dimensions, length by width: 878 feet by 18 feet, 854 feet by 20 feet, 430 feet by 18 feet, 2,000 feet by 18 feet, 740 feet by 26 feet, 1,500 feet by 18 feet, and 650 feet by 15 feet, and the total area surfaced amounted to 11,935 square yards. The depth to which the shell was spread varied from 2 inches to 13 inches, measured loose, according to the condition of the surface, and the compacted depth was about one-third the loose depth. Material to the extent of 1,037 cubic yards was moved in the excavation and 46,125 bushels of shells were used in surfacing. In all, 24,300 bushels of shells were delivered on the road at

$0.035 per bushel, while the remaining 21,825 bushels cost $0.045 delivered at the Naval Academy docks.

The total cost of the work, exclusive of depreciation and fuel for the roller, was $2,803.11, making the cost per square yard $0.19. The principal items of cost were as follows: Excavation, 1,037 cubic yards at $0.30 per cubic yard, $310.44; shaping the subgrade, $236.76; surfacing material delivered on the road, 24,300 bushels, at $0.035 per bushel, $850.51; surfacing material delivered at the docks, 21,825 bushels, at $0.045 per bushel, $982.12; hauling the surface material, $110.40; spreading the surfacing material, $156.44; rolling the surface, $155.16; and incidental expenses, $1.28.

EARTH ROADS.

Pangburn, Ark.—Work was begun on the River Road leading from Pangburn toward Cleburne County on September 2, 1912, and was completed on September 13, 1912. An earth road 1,000 feet long was constructed 30 feet wide.

The country is hilly and the natural soil from station 0 to station 8 is clay containing sandstone and shale. From station 8 to station 10, on the west side of the road, it is also clay and rock, but on the east side the soil is loam. There was no center cut and the maximum fill was 2 feet. The maximum grade remained 10 per cent, as it was before the improvement. The earth was loosened with a plow and picks, hauled in drag scrapers, and spread with shovels and a road grader. The presence of loose rock in the clay made excavation difficult. It was removed with picks and a bar by hand labor. The maximum haul was 120 feet and the average haul 40 feet. A retaining wall 27 feet long was built at station 8. It was made of the stone obtained in excavating and laid dry.

The equipment consisted of a road grader, a road plow, and hand tools, all of which were in poor condition. Labor cost $0.125 per hour, and teams cost $0.375 and $0.25 per hour. The total cost of the road was $166.75, which is at the rate of $0.05 per square yard, or $880.44 per mile. The principal items of cost were as follows: Clearing and grubbing, 3,333 square yards, at $0.005 per square yard, $17; earth excavation and embankment, 500 cubic yards, at $0.18 per cubic yard, $90; rock excavation, 42¾ cubic yards, at $1 per cubic yard, $42.75; fine grading, 3,333 square yards, at $0.0044 per square yard, $14.50; and retaining wall, 5 cubic yards, at $0.50 per cubic yard, $2.50.

Zona, Fla.—Work was begun on February 4, 1913, on a road leading eastward from the State canal, about one-half mile above Zona. The road was built between and parallel to two tributary ditches to this canal, which were about 40 feet apart, and the material excavated from the ditches was used in grading the road. The work was in the nature of an experiment, having for its object the development of a satisfactory road surface composed of the native black muck, muck and sand, or coralline rock. The road is in the Everglade district, and the material obtained from the ditches was of three distinct types. The top soil, to the depth of from 2 to 5 feet, was black muck, which is in reality decayed organic matter, finely honeycombed, very light and fluffy when dry, and very difficult to consolidate. Below this muck a layer of fine sand was encountered varying in depth from 1 to 3 feet. The formation below the sand was coralline rock.

The section of road improved was 6,800 feet long and 18 feet wide, making a total area of 13,600 square yards.

It was originally intended that the first 2,000 feet would be surfaced with coralline rock obtained from the banks of the State canal, and that the remaining distance should be divided into two experimental sections, the first to be surfaced with muck or loam, which was to be consolidated by a light tamping roller, and the second to be surfaced with muck and sand spread in alternate layers and mixed by puddling with the tamping roller.

At the time the work was done labor and teams were difficult to obtain and no roller of any description was to be had. The specifications were drawn up, however, for a light tamping roller, and it was agreed by the interested parties to postpone the work until the roller could be made and labor and teams should become available. The work was accordingly discontinued on February 21, 1913, but it is hoped that it will be resumed and prosecuted at some future time when the conditions are more favorable.

The cost of the work done, which consisted in spreading the material from the ditch banks and shaping the road, was $267.20, which is at the rate of $0.019 per square yard. Labor cost $2 per day and no teams were employed.

Ord, Nebr.—Work was started on an earth road running from Ord eastward toward Spelts on August 3, 1912, and finished on August 17, 1912. The land adjacent to the road is level, while the soil is loam with a quicksand subsoil from station 0 to station 30, and loam with a clay subsoil from station 30 to station 50—the end of the road. Earth to the amount of 2,462 cubic yards was moved, of which 180 cubic yards was loosened with a plow and hauled an average distance of 250 feet with Fresno and drag scrapers; 1,550 cubic yards was loosened and loaded with an elevating grader and hauled an average distance of 2,370 feet in slat-bottom wagons; and 732 cubic yards was placed with the elevating grader. The maximum cut was 0.6 foot and the maximum fill 1.6 feet. The maximum grade was reduced from 2 per cent to 1.6 per cent.

The road was graded 5,000 feet to a width of 24 feet, and the total area was 13,333 square yards. The crown of the roadway was three-fourths inch to 1 foot. Reinforced concrete culverts, 3 by 2 feet and 26 feet long, each containing 11.6 cubic yards of concrete and 600 pounds of steel, were constructed at stations 7+95 and 26+37, and a 12-inch vitrified clay-pipe culvert at station 33+80 was lengthened 6 feet and supplied with concrete end walls.

The equipment consisted of a 10-ton oil-burning tractor, an elevating grader, a road machine, drag and Fresno scrapers, slat-bottom wagons, and hand tools. The tractor, which was used for drawing the grader, consumed 270 gallons of petroleum. Labor cost $2; teams, $4; and foremen, $4.50 per 10-hour day. Fuel oil cost $0.095 per gallon; cement, $1.84 per barrel; sand and gravel, $0.50 per cubic yard; and steel, $0.026 per pound.

The total cost of the road was $743.88, which is at the rate of $0.056 per square yard. The principal items of cost were: Grading, $487.42; shaping the roadway, $38.30; vitrified clay pipe (6 feet 12 inches), $1.35; end walls, $11.88; concrete culverts, $203.93; and grading the road intersection, $1. The costs of all materials are included above under the proper items.

Calypso, N. C.—On September 16 and 17, 1912, a representative of the Office of Public Roads who had supervised the construction of an object-lesson sand-clay road at Calypso, assisted the local road officials in getting work under way on an earth road. During these two days a section of road 800 feet long was partially cleared and graded, though no part of this was entirely finished.

Twenty-one dollars and twenty cents was spent for this work, of which $6 was spent for clearing and grubbing and $15.20 for grading. Instructions were given by the office representative for continuing the work.

Madison, S. Dak.—An earth road leading southward from Madison toward Clarena, known as the Meridian Road, was begun on July 30, 1912, and a section 6,092 feet long was completed by August 6, 1912. The land adjacent to the road is rolling, and the soil is prairie loam with a clay subsoil. The maximum fill was 1.7 feet, and there was no cut. The maximum grade remained approximately 3.9 per cent, as it was before the improvement. Two corrugated metal culverts 26 feet long were constructed; one, 12 inches in diameter, at station 27+35 and one, 15 inches in diameter, at station 55+00.

The road was graded to a width of 44 feet, making a graded area of 29,783 square yards. Earth, 2,708 cubic yards of which was moved, was for the greater part placed with an elevating grader hauled by a gas tractor, though plows and scrapers were used when more practicable. After the rough grading was completed the road was harrowed with a disk harrow and then shaped and compacted with a blade grader hauled by the gas tractor.

The equipment consisted of 1 gas tractor, one 8-horse blade grader, 1 elevating grader, one 4-horse blade grader, 2 small wheel scrapers, 1 drag scraper, 1 plow, 1 disk harrow, 1 spike harrow, and hand tools. The gas tractor, with operator and supplies, was hired at a cost of $25 per 10-hour day. Labor cost $2.50 and teams $4.50 per 10-hour day.

The total cost of the road to the community was $236.92, or, disregarding the cost of culverts, $182.80, which is at the rate of $0.0061 per square yard. The principal items of cost were: Excavation, at $0.0405 per cubic yard, $109.82; fine grading, at $0.0017 per square yard, $50.48; compacting, at $0.0008 per square yard, $22.50; culvert pipe, $49.92; and labor on culverts, $4.20.

Dickson, Tenn.—Work was started on November 12, 1912, on an earth road leading southwest from Dickson and was discontinued on November 29, 1912, after a section 5,280 feet long had been graded to a width of 24 feet in cuts and 18 feet in fills. The adjacent land is hilly and the soil varies from loam to solid rock, with rock predominating. With the limited amount of funds available for this work, it was impossible to reduce the steep maximum grade of 10.1 per cent materially or to make the general character of the work such as was desired.

The total area graded was 11,710 square yards, while the volume of earth excavation was 1,700 cubic yards and the volume of rock excavation 25 cubic yards. The maximum cut was 3.6 feet and the maximum fill 2.5 feet. Earth was loosened with plows and hauled with drag scrapers and wagons or moved with a road machine. Rock was excavated by hand drilling and blasting with 40 per cent dynamite, and the loosened material was moved by hand. A 12-horsepower traction engine was used for plowing and also for pulling the road machine.

Two timber culverts were constructed—one at station 25+18 having a span of 2 feet, a height of opening of 1 foot 4 inches, and a length of 15 feet, and the other, at station 41+48, having a span of 3 feet, a height of opening of 2 feet, and a length of 24 feet.

The equipment consisted of one 12-horsepower traction engine, one 300-gallon tank, 2 plows, 2 No. 2 drag scrapers, 1 reversible road machine, and hand tools. The traction engine, road machine, and tank were hired as one outfit for $9 per 10-hour day, and this price included all charges for operators, fuel, etc. Labor cost $1.25 and teams $3 per 10-hour day.

The total cost of the road to the community was $429.65, which is at the rate of $0.037 per square yard. The principal items of cost were: Clearing, $1.13; excavation (earth), at $0.194 per cubic yard, $330.14; excavation (rock), at $1.275 per cubic yard, $31.88; dynamite for rock excavation, $7.15; constructing culverts, $4.30; materials for culverts, $12.95; fine grading, $12.60; superintendence, $28; and incidentals, $1.50.

Fannett, Tex.—An earth road, leading from Fannett northwest toward Nome, was constructed between May 5, 1913, and June 13, 1913. The road traverses marsh or rice land, having a black, waxy soil. The maximum fill was 3 feet, and the average fill throughout the length of the road was 1 foot.

The maximum grade was 0.5 per cent. The material composing the embankment was loosened with plows, hauled with drag scrapers, and spread with a road grader. After the fill was brought to approximately 1 foot below grade with the local soil it was completed with a natural mixture of sand and loam which possesses fair binding and wearing qualities. The loam was hauled in ordinary farm wagons with slat bottoms for an average distance of three-eighths mile and spread with a road grader. The total length of the road constructed was 5,280 feet, and the width of the grade was 24 feet and of the loam surface 14 feet, making a total graded area of 14,080 square yards and a surfaced area of 8,213 square yards. The loam was spread to a depth of 16 inches loose and compacted to 12 inches. The crown of the finished roadway was approximately 1¼ inches to 1 foot. The material removed in grading amounted to 4,694 cubic yards, and 2,400 cubic yards of sandy loam was used in surfacing. In making the improvement it was necessary to raise two old wooden bridges to conform to the new grade. Labor cost $1.75 and teams $5 per 10-hour day.

The total cost of the road to the community was $1,733.24, which is at the rate of $0.211 per square yard of surfaced area. The principal items of cost were as follows: Excavation, 4,694 cubic yards, at $0.171 per cubic yard, $819.62; shaping the subgrade, 14,080 square yards, at $0.0026 per square yard, $36.75; clearing the right of way, $7; raising the old bridges, $17.50; loading sandy loam, 2,400 cubic yards, at $0.107 per cubic yard, $256.37; hauling the sandy loam, at $0.235 per cubic yard, $564.50; and spreading the sandy loam, at $0.013 per cubic yard, $31.50.

Palacios, Tex.—Work was begun on the Turtle Bay Road leading northwest from Palacios on January 27, 1913, and discontinued on March 11, 1913, with the loss of 10 days on account of rain. It was originally intended that this road should be surfaced with mud-shell obtained from Matagorda Bay at the mouth of the Colorado River. After the road was graded and drained, however, for a total length of 14,900 feet, it was decided to postpone the surfacing until the spring of 1914. The land traversed by this road is approximately level, and the soil consists of sandy loam from station 0 to station 320, and gumbo throughout the remaining distance. Wooden culverts were constructed at stations 43+35, 51+30, and 59; and concrete culverts at stations 11+20, 18, 59+50, and 97. The road was graded 50 feet wide for approximately 4,600 feet and 45 feet for the remaining distance, making a total graded area of approximately 75,800 square yards. The total cost to the community of this road was $2,554, which is at the rate of $0.034 per square yard. Labor cost $1.75, and teams $4 for a 10-hour day.

It is anticipated that this work will be completed under the supervision of the Office of Public Roads, and that a detailed statement of costs will appear in a later report.

Bayfield, Wis.—A section of earth road was constructed in Bayfield County in the Redcliff Indian Reservation. This road leads north from Redcliff toward Sand River and is known as the Redcliff Road. The road improved is only a short section of what it was planned to improve. Plans were furnished for 3½ miles of road, and this work has been pushed to completion during the past season by the local authorities. The work of grading was begun on June 10, 1913, and completed on June 13, 1913. The adjacent land is rolling and the soil is sandy loam from station 49 to station 51 and clay from station 51 to station 52+20. The section improved extends from station 49 to station 62+20 of the survey and is new location. The maximum cut was 3 feet and the maximum fill 3½ feet. The maximum grade was 5 per cent and the minimum grade 2 per cent. Labor cost $2 and teams $5 per 10-hour day.

The equipment consisted of 1 road machine, 6 No. 1 drag scrapers, 2 plows, picks, shovels, etc. The only work done consisted in grading and shaping the road.

The total length graded was 1,320 feet. The width in cuts was 27 feet and in fills 24 feet. The total graded area was 3,960 square yards. The right of way was cleared to a width of 66 feet. The roadway was given a crown of three-quarters inch to 1 foot. In all, 745 cubic yards of earth was moved in the excavation and hauled an average distance of 75 feet, with a maximum haul of 300 feet. The total cost of the road to the community was $238.50, which is at the rate of $0.06 per square yard. The principal items of cost were: Excavation, 745 cubic yards at $0.20, $149; shaping with the road machine, 3,960 square yards at $0.006 per square yard, $24.50; and clearing and grubbing the right of way, $65.

INSPECTION OF OBJECT-LESSON ROADS.

The arrangement adopted last year for providing for systematic inspection of work in progress and of projects submitted to this office by the local officials was so successful in saving time and expense that it will be continued.

A chief inspector has been appointed, and during the past year has reported as follows: Inspections of old object-lesson roads, 3; inspections of work in progress under field men, 14; and preliminary inspections of proposed work, 5. Special assignments of a confidential nature were covered at Raleigh, N. C., relative to the improvement of post roads in that State; at Elkhart, Ind., relative to county contract work in progress; and at Knoxville, Tenn., relative to the cost of macadam construction and a case at law involving contractors' anticipated profits. Special assignments were also covered at Letchworth Park, N. Y., in connection with the creation of a system of roads within the park limits; at Augusta, Me., for a study of the State highway system and a draft of a proposed State law establishing a highway commission, etc. Special advice and inspections of a routine nature were made at Anaconda, Mont., Nappanee, Ind., Gatesville, N. C., and Arcadia, Fla.

The chief inspector also made nine general inspections in connection with post-road projects under the Post Office appropriation act of August, 1912.

UNFINISHED WORK.

Object-lesson roads were begun at St. Johns, Ariz., Morgantown, N. C., and Appomattox, Va., during the latter part of the last fiscal year and are still in course of construction. These roads will be described in the report on the field work of the Office of Public Roads for 1913–14.

EXPERIMENTAL ROADS, 1912–13.

The office conducted a series of experiments in road building at the following places during the past fiscal year: Miami, Fla.; Chevy Chase, Md.; Rockville Pike, Montgomery County, Md.; and the Agricultural Department grounds, Washington, D. C. These will be described in greater detail in the regular annual progress report on experiments in dust preventives and road binders. A brief description of each road is, however, given below.

EXPERIMENTS AT MIAMI, FLA.

On June 9, 1913, at the request of the board of county commissioners of Dade County, Fla., an engineer was assigned from the Office of Public Roads to supervise the construction of a series of test sections on the Biscayne Drive, about 2 miles north of Miami, for the purpose of investigating the practicability of a bituminous-surface treatment for the local roads. These roads have all been surfaced with a soft oolitic limestone, known locally as marl, coralline rock, or limestone, deposits of which are found in various sections of the county. Six separate experiments were made on as many sections of road, and the total area surfaced was 2,804 square yards.

EXPERIMENTAL ROAD AT CHEVY CHASE, MD.

The work at Chevy Chase is the continuation of the series of experiments begun in 1911, made possible through the appropriation by Congress of a special fund for carrying on such work. Various experiments in surface treatment were conducted on the section of water-bound macadam constructed in the past fiscal year.

In continuation of the 1911 experiments, additional sections were constructed upon a section of Connecticut Avenue, beginning at Bradley Lane and extending to the loop of the Capital Traction Co's. tracks at Chevy Chase Lake, The experiments are six in number, and comprise sections of bituminous concrete, concrete, oil-cement concrete, bituminous-surfaced concrete, surface treatments, and vitrified brick. Up to date about 16,378 square yards have been surfaced, as follows: Bituminous concrete, 2,898 square yards; concrete, 3,013 square yards; oil-cement concrete, 1,744 square yards; bituminous-surfaced concrete, 4,178 square yards; surface treatments, 2,490 square yards; and brick, 2,055 square yards.

In addition to the construction of these sections, the entire series of experiments was also systematically maintained.

EXPERIMENTAL WORK ON ROCKVILLE PIKE, MONTGOMERY CO., MD.

A part of the special fund appropriated for experiments in road improvement, together with funds furnished by the community, is being devoted to resurfacing the Rockville Pike in Montgomery County, Md. This road will be resurfaced with limestone macadam throughout its length and the surface will be treated with various bituminous materials in conjunction with gravel, trap-rock screenings, and limestone screenings. The experiments are being made to determine the best methods of maintaining macadam roads free from dust. During the past fiscal year about 26,675 square yards were surfaced with water-bound macadam.

EXPERIMENTS ON THE AGRICULTURAL DEPARTMENT GROUNDS, WASHINGTON, D. C

Several sections of driveway on the Agricultural Department grounds were given a surface treatment in October, 1912. This work was done on some of the same sections which have already been experimentally treated and decribed in former progress reports of the Office of Public Roads. A total of 4,485 square yards of surface was treated in 1912.

MEMPHIS-TO-BRISTOL HIGHWAY.

Work on the eastern division of the Memphis to Bristol Highway from Nashville to Bristol, which was started in January, 1912, was continued during the first part of the fiscal year 1912–13. The funds raised to defray the expenses of an engineer under an arrangement made with the office were exhausted in December, 1912, and connection with the work was severed.

Work was done in 10 counties—Cannon, Carter, Cumberland, Greene, Hamblen, Loudon, Roane, Warren, Washington, and White. On account of the badly sunken and worn condition of the existing roads together with the excessive grades, a new location was made on a large portion of the route, particularly on the section crossing the Cumberland Mountains, where the plans call for a new location throughout practically the entire distance of 55 miles.

All new location was made permanent, and it was frequently necessary to institute condemnation proceedings before the new right of way could be secured. The general maximum grade adopted was 5 per cent, but in one or two instances on the mountain sections it was necessary to use a 6 per cent grade on short stretches. Concrete or stone masonry was used in all the larger drainage structures, while corrugated metal or vitrified clay pipe was used for the smaller drainage areas.

Preliminary surveys were made on 148.6 miles and final location was established for 87.3 miles. On December 15, 1912, of the total unimproved mileage between Nashville and Bristol—152.3 miles—a total of 52 miles of grade and 17.4 miles of surfacing was finished, while uncompleted contracts and work being done by force account assured a total of 75.5 miles of finished grade and 52.5 miles of surfaced road. The status of the work on a percentage basis was: Unimproved mileage graded, 34.1 per cent; unimproved mileage surfaced, 11.5 per cent; unimproved mileage which will be graded upon completion of contracts, 49.6 per cent; unimproved mileage which will be surfaced upon completion of contracts, 34.2 per cent; and unimproved mileage remaining between Nashville and Bristol upon completion of contracts, 21.8 per cent.

The total quantities, together with the average unit costs, of the work done on the 52 miles of grade and 17.4 miles of surfacing finished were as follows: Clearing and grubbing 76.45 acres, at $54.13 per acre; earth excavation, 225,513 cubic yards, at $0.251 per cubic yard; loose-rock excavation, 306.8 cubic yards, at $0.39 per cubic yard; solid-rock excavation, 15,215.9 cubic yards, at $0.812 per cubic yard; overhaul on excavation, 44,446 yard stations, at $0.01 per yard station; concrete, 686.1 cubic yards, at $7.94 per cubic yard; masonry, 255.4 cubic yards, at $6 per cubic yard; slag and gravel, 21,826 cubic yards, at $0.634 per cubic yard; macadam, 18,332.5 cubic yards, at $1.57 per cubic yard; 1,846 linear feet of 12-inch corrugated metal pipe, at $0.74 per foot; 1,038 linear feet of 15-inch corrugated metal pipe, at $0.90 per foot; 474 linear feet of 18-inch corrugated metal pipe, at $1.02 per foot; 832 linear feet of 24-inch corrugated metal pipe, at $1.48 per foot; 40 linear feet of 36-inch corrugated metal pipe, at $2.99 per foot; 26 linear feet of 48-inch corrugated metal pipe, at $4.29 per foot; 786 linear feet of 12-inch vitrified clay pipe, at $0.58 per foot; 190 linear feet of 15-inch vitrified clay pipe, at $0.78 per foot; 482 linear feet of 18-inch vitrified clay pipe, at $0.97 per foot; 97½ linear feet of 20-inch vitrified clay pipe, at $1.125 per foot; 764 linear feet of 24-inch vitrified clay pipe, at $1.76 per foot; 39,054 pounds of steel I beams and rods, at $0.045 per pound; 9,500 feet b. m. of bridge lumber, at $35 per thousand; and crowning and shaping, 1,181,800 square yards, at $0.01 per square yard.

The average earth excavation per mile was 4,326 cubic yards, and the average rock excavation per mile was 342 cubic yards.

The project was strictly a cooperative enterprise, and each county provided the funds necessary to build the section of road within its boundaries. In several counties the funds raised were not available during the year 1912 and no actual construction could be attempted. The progress of the work as a whole would undoubtedly have been much better if the funds in these counties had been available.

BRIDGE WORK, 1912–13.

The office constructed bridges at Drake, S. C., and at Cheraw, S. C. Descriptions are given below.

DRAKE, S. C.—A 25-foot span I-beam bridge with concrete floor, having a clear roadway 16 feet wide, was constructed at Drake. Work began on July 29, 1913, and the bridge was entirely finished by August 23, 1913. It was necessary to provide sluice gates in connection with this bridge, and the construction was on that account made more difficult than it otherwise would have been.

The abutments and wing walls contained 152.2 cubic yards of concrete, which was mixed in the proportion 1 : 3 : 6, while the floor slab and parapets contained 12.6 cubic yards of concrete mixed in the proportions 1 : 2 : 4. It was necessary to use 175 barrels of cement, 70 cubic yards of sand, 189.6 tons of gravel, nine 15-inch 42-pound I beams 28 feet long, 600 square feet of expanded metal, 56 linear feet of pipe railing, and 3,744 board feet of lumber. Convict labor and county-owned teams were used.

The total cost of the bridge, which includes the necessary convict camp expenses, was $1,350.62. The principal items of cost were: Excavation, $18; building forms, $58.50; laying concrete, $68.70; building sluice gates, $10; placing I beams, $5.40; removing forms and back filling, $12.30; 175 barrels of cement, at $1.70 per barrel, $297.50; 189.6 tons of gravel, at $1.45 per ton, $274.92; nine 15-inch 42-pound I beams, at $42.04 per beam, $378.36; 600 square feet of expanded metal, at $0.044 per square foot, $26.40; paint for I beams, $3.50; 56 linear feet of pipe railing, at $0.73 per foot, $40.88; 3,744 board feet of timber, at $15 per thousand, $56.16; hauling gravel, $45; hauling sand, $50; and hauling lumber, $5.

CHERAW, S. C.—At Cheraw, S. C., a concrete bridge, which had been badly damaged, was repaired under the supervision of the office. The repair work began on August 27, 1913, and was finished on September 14, 1913. The total cost of the work was $225.40, and the principal items of cost were: Hauling the materials, $57; building dams and pumping water, $27.75; work on the forms, $8; mixing and placing the concrete, $41.25; 924 feet board measure of lumber, at $15 per thousand, $13.86; 102 sacks of cement, at $0.47 per sack, $47.94; and wheelbarrows, drills, bolts, buckets, nails, etc., $29.60.

PREPARATION OF PLANS.

Typical designs were prepared during the past fiscal year for concrete bridges and culverts ranging in span from 2 feet to 16 feet and for steel bridges ranging in span from 30 feet to 150 feet. About 350 blue-print copies have already been furnished from these plans for use at specific points. Special designs, prepared to cover cases for which the typical designs could not be used, were distributed by States as follows: Arizona, 1; Florida, 1; Iowa, 3; Kentucky, 7; Maryland, 4; Mississippi, 6; Nebraska, 2; North Dakota, 1; South Carolina, 2; Virginia, 1; and Wisconsin, 1.

BRIDGE INSPECTIONS.

Thirty-five separate inspections were made during the fiscal year 1912–13 in connection with which the local officials were given advice as to the most practical types of bridges for the various locations in question and as to the advantages to be derived from employing competent engineering supervision for all bridge work. These inspections were distributed by States as follows: Arizona, 1; Arkansas, 1; Iowa, 10; Kentucky, 9; Maryland, 3; Mississippi, 3; North Carolina, 4; South Carolina, 2; Virginia, 1; and Wisconsin, 1.

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